SALMON ESCAPEMENT ESTIMATES

INTO TOGIAK RIVER USING SONAR,

TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA,

1987, 1988, and 1990

David B. Irving
James E. Finn
James P. Larson

U.S. Fish and Wildlife Service
King Salmon Fishery Resource Office
P.O. Box 277
King Salmon, Alaska 99613

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ABSTRACT

We began a three year study in 1987 to test the feasibility of using sonar in the Togiak River to estimate salmon escapements. Current methods rely on periodic aerial surveys and a counting tower at river kilometer 97. Escapement estimates are not available until 10 to 14 days after the salmon enter the river. Water depth and turbidity preclude relocating the tower to the lower river and affect the reliability of aerial surveys. To determine whether an alternative method could be developed to improve the timeliness and accuracy of current escapement monitoring, Bendix sonar units were operated during 1987, 1988, and 1990. Two sonar stations were set up opposite each other at river kilometer 30 and were operated 24 hours per day, seven days per week. Catches from gill nets with 12, 14, and 20 cm stretch mesh, a beach seine, and visual observations were used to estimate species composition. Length and sex data were collected from salmon caught in the nets to assess sampling bias.

In 1987, sonar was used to select optimal sites and enumerate coho salmon. In 1988 and 1990, the sites identified in 1987 were used to estimate the escapement of five salmon species. Sockeye salmon escapement was estimated at 512,581 and 589,321, chinook at 7,698 and 15,098, chum at 246,144 and 134,958, coho at 78,588 and 28,290, and pink at 96,167 and 131,484. Sonar estimates of sockeye salmon were two to three times the Alaska Department of Fish and Game's escapement estimate based on aerial surveys and tower counts. The source of error was probably a combination of over-estimating the total number of targets counted by the sonar and by incorrectly estimating species composition.

Total salmon escapement estimates using sonar may be feasible but several more years of development are needed. Because of the overlapped salmon run timing, estimating species composition appears the most difficult aspect of using sonar for management. Possible improvements include using a larger beach seine or selecting gill net mesh sizes evenly spaced between 10 and 20 cm stretch mesh.

Salmon counts at river kilometer 30 would reduce the lag time between salmon river entry and the escapement estimate to 2-5 days. Any further decrease in lag time, however, would require moving the sonar operations downriver into less desirable braided portions of the river.

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INTRODUCTION

The Togiak River, on Togiak National Wildlife Refuge, has runs of chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), pink (*O. gorbuscha*), and sockeye (*O. nerka*) salmon (U.S. Fish and Wildlife Service 1986). These fish support subsistence, commercial, and sport fisheries that are important to the culture and economy of the local area. The Alaska Department of Fish and Game (Department) manages the escapement for the Togiak River at 10,000 chinook, 50,000 coho, and 150,000 sockeye salmon annually (Alaska Department of Fish and Game 1990). No specific Togiak River escapement goal for chum salmon has been set, although the goal for the Togiak District, which includes fish returning to several river systems, is 200,000. No escapement goal is set for pink salmon because they are not targeted by the commercial fishery. To conserve the resource and provide a sustained yield, accurate and timely escapement estimates are necessary for the management of Togiak River salmon.

The Department uses tower counts, aerial surveys, and commercial catch data to manage Togiak River escapement (Alaska Department of Fish and Game 1990). At present, sockeye salmon escapement estimates are based on tower counts at Togiak Lake, 97 river kilometer (Rkm) from Togiak Bay. Fish were counted at the tower 10 to 14 days after they escaped the commercial fishery in Togiak Bay (Brannian 1982). Because commercial fishing is permitted about four days per week (Monday through Thursday), two fishing periods can occur before migrating fish reach the tower, a considerable lag time for in-season management purposes.

Aerial surveys are used to supplement the tower counts, but they are often curtailed due to weather and turbid water conditions. The result can be unequal coverage within a season and between years. Aerial surveys provide only instantaneous, rather than total escapement estimates.

To provide a more timely escapement estimate, the Department has modeled the relationship between commercial fishing catch per unit effort and sockeye salmon escapement. The model is a relatively good estimator of sockeye salmon escapement when commercial fishing is maintained at a fixed number of openings per week (Brannian 1982). However, during years when runs are weak or if fishing pressure increases, the number of openings vary and the estimates become inaccurate.

As an alternative to tower counts, aerial surveys, and catch modeling, sonar has been successfully used to estimate daily salmon escapement in Alaska (Barton 1986, Woolington and Bue 1989, Daum et al. 1992). Unlike these other methods, sonar counters are not dependent on water clarity, weather conditions, or consistent commercial fishing effort. Present sonar counters, however, are unable to distinguish between salmon species with over-lapping migration timing. Species composition of the migration run is determined by making direct tower observations, collecting fish at weirs, or in seines and gill nets. The species composition is then used to apportion daily sonar escapement estimates.

The Department studied the practicality of using Bendix sonar to estimate salmon escapement into the Togiak River in 1983 and 1984 (R.E. Minard, Alaska Department of Fish and Game, personal communication). The sonar was operated from late July through mid August in 1983 below the Gechiak River (Figure 1). In 1984, the sonar system was operated from late June to late July at several locations along the Togiak River. This research showed that the best sonar site was located about one mile upriver from the Pungokepuk River (Figure 1). Although the 1983 and 1984 sonar studies identified a suitable site to operate the sonar, problems with species apportionment were encountered. Research was not conducted in 1985 and 1986 due to funding constraints.

In 1987, the King Salmon Fishery Resource Office began a three year study to further test the feasibility of using sonar to estimate salmon escapement into the Togiak River (Finn 1990). The 1989 sonar season was postponed until 1990 due to funding constraints. Study objectives were:

(1) to determine the feasibility of using sonar to estimate Togiak River chinook, chum, coho, sockeye, and pink salmon escapement; and

(2) to estimate sockeye salmon migration time from the river mouth to the sonar site.

During the 1987 field season, sonar sites with potential for enumerating salmon escapement were found and alternative sites were tested (Finn 1990). Sonar counters were operated from 12 August-22 September 1987; after the peak migration period of all salmon species except coho. The coho salmon escapement was estimated at 68,427, although this estimate is probably not accurate. Slow fish swimming speeds and milling behavior in and around the ensonified sample area caused over-counting problems in 1987. In addition, sonar operations had to be relocated or shut down several times because of high water.

The emphasis of the 1988 and 1990 field seasons was to refine sonar use by operating for sample periods that bracketed the majority of the migration for all five salmon species and to increase gillnet and beach seine sampling effort. The sonar counters were modified before the 1988 season to compensate for the slow fish swimming speeds encountered in the 1987 study.

This final report presents the results of the 1988 and 1990 sampling season. These data, along with the information from the 1987 progress report (Finn 1990), are used to discuss the feasibility of using sonar to enumerate adult salmon in the Togiak River.

STUDY AREA

Togiak River is located in southwestern Alaska and 70% of the river drainage is situated within the Wilderness Area of the Togiak National Wildlife Refuge (Figure 1). The climate is influenced by the maritime regime of Bristol and Kuskokwim Bays, and the continental regime of interior Alaska. Annual minimum and maximum air temperatures average

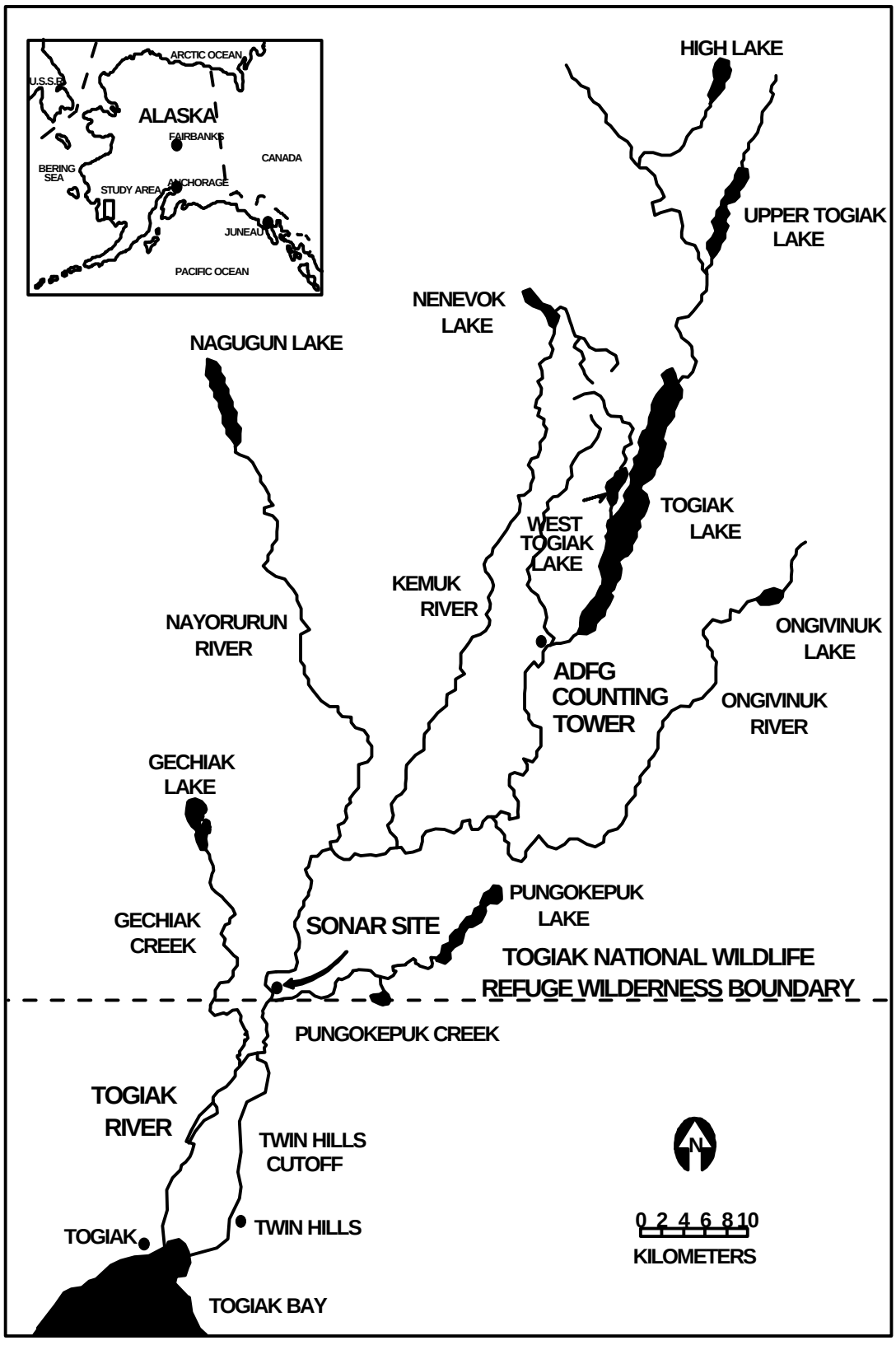

Figure 1.-Location of the sonar site, Alaska Department of Fish and Game counting tower, and major tributaries of the Togiak River, Alaska.

about -16°C and 16°C. Average annual precipitation is about 63 cm. The snowfall ranges from 152-172 cm along the coast to greater than 381 cm in the mountains (U.S. Fish and Wildlife Service 1986).

Togiak River originates at Togiak Lake (3,884 hectares) and flows about 97 Rkm to the south before draining into Togiak Bay. The Togiak River drainage (5,178 km^2) is a complex system with five major tributaries and nine major lakes (Figure 1). At Rkm 21, a channel of the Togiak River diverges from the main stem to form the Twin Hills Cutoff. The Twin Hills Cutoff parallels the Togiak River and drains into Togiak Bay 1.6 km to the east. Above Rkm 21, the river is primarily confined to one channel. Below Rkm 21, the river is often braided into multiple channels.

At Rkm 30, the sonar site, the river is confined to a single channel 110 m wide with a maximum depth of 2.5 m at low water. During the summer, the river will fluctuate 1.8 m between low water and flood stage.

METHODS

Sonar Operation

Bendix Corporation 1977 and 1979 adult salmon sonar counters were used in the study. Bendix Corporation (1981), Tarbox et al. (1983), and Gaudet (1984) explained the sonar theory, equipment setup, operation, and calibration of Bendix sonar counters.

The sonar counters were modified before the 1988 season to compensate for the slow fish swimming speeds that were observed in 1987 (Finn 1990). In 1987, the sonar signal rate was set to operate between 0.000-0.999 pulses/s. In 1988 and 1990, the sonar signal rate for the 1977 counter was modified to operate between 0.000-2.999 pulses/s and the 1979 counter between 0.000-3.999 pulses/s. The sonar counters were preset to stratify the sonar beam into 12 equal sectors and print fish counts for each sector every hour. Sector 1 was closest to the transducer.

King (1984) outlined the river characteristics required for riverine sonar operation. The 1987 sonar site at Rkm 30 (Finn 1990) was used throughout the study (Figure 1). Four sites were selected on the east bank (E1, E2, E3, and E4) and two on the west bank (W1 and W2) for sonar equipment placement in 1988 and 1990 (Figure 2). East bank sites E1 and E2 and west bank site W1 were the same sites used in the 1987 study (Finn 1990). East bank site E3 and west bank site W1 were the primary sonar sites. The river channel depth profile was measured using a Lowrance Eagle Mach 1 recording echo sounder. A temporary staff gauge was installed during 1988 and 1990 at the east bank site E3. The relative water level was measured daily.

A sonar counter and transducer were set up on each side of the river with the transducers offset about 50 m. The transducer was mounted on a portable tripod which allowed for manual horizontal and vertical aiming

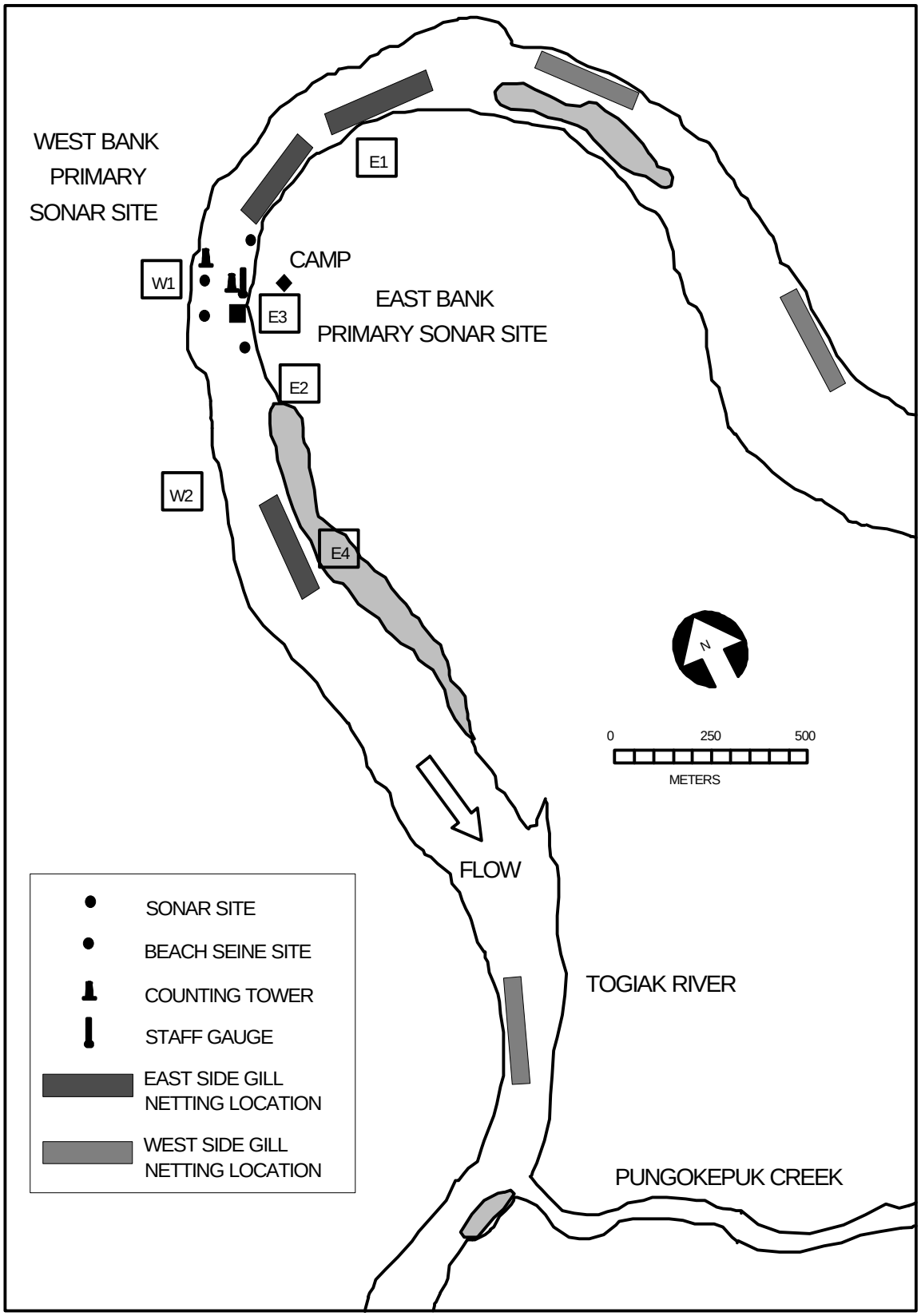

Figure 2.-Location of the sonar counters, netting locations, and field camp on the Togiak River, Alaska during 1988 and 1990.

of the sonar beam. A deflection weir was placed about 1 m downstream of the transducer and extended from the bank to approximately 1 m beyond each transducer. The weir was approximately 1 X 10 m and constructed with steel fence posts and wire or plastic fencing with 5 X 10 or 5 X 5 cm openings. The weir prevented upriver migrating fish from passing behind the transducer.

The sonar beam was aimed along the bottom such that the oscilloscope detected the bottom evenly along the sampling area, but the reflected signal was weak enough that sonar equipment did not count the substrate as a valid target. To determine whether the sonar counter was aimed and counting correctly, a target was pulled through the expected sonar beam counting range. The target was constructed from a weighted quart jar filled with water and two to three ping pong balls. The ping pong balls simulated a fishes swim bladder. The target was attached to a monofilament line and was pulled through the sonar beam. When the target crossed the sonar beam, it registered a sharp spike or trace on the oscilloscope and was recorded as a fish by the sonar counter.

Sonar Calibration

Sonar counters in 1988 and 1990 were calibrated by comparing valid targets on the oscilloscope with counts registered by the sonar counter every four to eight hours, with a minimum target goal of 30 oscilloscope counts per calibration. A comparative value (Q) was calculated by dividing sonar counts by oscilloscope counts. The sonar counter was assumed to be counting correctly when $Q = 1$.

The signal rate was adjusted to maintain the daily Q within a 20% deviation range ($0.80 \leq Q \leq 1.20$). The formula used to calculate a new signal rate (Ping) was:

$$PING_{NEW} = [((PING_{OLD} * Q) - PING_{OLD}) / 2] + PING_{OLD}$$

where:

PING = The NEW (after calibration) or OLD (before calibration) signal rate.

Q = The sonar count / oscilloscope count.

Visual counts were used periodically to validate the oscilloscope counts. The estimated Q from tower and oscilloscope counts were compared using a t-test at " = 0.05. The comparisons were limited to Q estimated from sectors 1 - 4 of the sonar counter because of the limited range of the tower counts.

A BioSonics chart recorder (Model #115) was used to generate a permanent (paper) echogram of fish passing through the sonar beam. The chart recorder was operated to determine whether it was a feasible alternative to the oscilloscope for calibrating the sonar counter. The calibration value (Q) from the echogram and oscilloscope count were compared using t-tests and ANOVA (Sokal and Rohlf 1981) at the " = 0.05 level.

Sonar Counts

The hourly and daily sonar counts required two adjustments. The first adjustment compensated for missing hourly or daily sector counts. These resulted from either false counts caused by debris, hard rain, and passing boats; or missed counts caused from low water levels, periods when the transducers were moved, or equipment failure. Missed hourly or daily sector counts were estimated by averaging the two hourly or daily counts before and after the missed sector count. For example, to estimate the daily count for missed day 3, the daily counts for day 1, 2, 4, and 5 were summed and divided by 4. The second adjustment corrected the daily count when the daily *Q* was not equal to 1. The adjusted daily sonar count estimate used in 1988 and 1990 was modified from the estimate used in 1987 (Finn 1990). The adjusted daily sonar count modeled after Simmons and Daum (1989) was:

$$\hat{C}_{ADJ} = [(\sum O_A / \sum C_A) * \sum T_A] + \sum[(O_B / C_B) * T_B]$$

Where:

$\hat{C}_{ADJ}$ = The adjusted daily count.

O_A = Oscilloscope count during calibration period when the signal rate control is not changed.

C_A = Sonar count during calibration period when the signal rate control is not changed.

T_A = Total sonar count during four to eight-hour calibration period when the signal rate control is not changed.

O_B = Oscilloscope count during calibration period when the signal rate control is changed.

C_B = Sonar count during calibration period when the signal rate control is changed.

T_B = Total sonar count during the four to eight-hour calibration period when the signal rate control is changed.

Species Apportionment

The species apportionment of the adjusted daily sonar counts was determined from the species composition based on gill net and beach seine catches and visual counts. Three different gill nets were used to sample migrating salmon: a 18 m by 2.4 m gill net of 20 cm stretched mesh; a 30.5 m by 2.4 m gill net of 14 cm stretched mesh; and a 30.5 m by 2.4 m gill net of 12 cm stretched mesh. Mesh size selection was based on the mesh sizes used by the commercial fishery to catch chinook,

pink and sockeye salmon. The beach seine was 45 m by 2.4 m and consisted of 7.6 cm stretch mesh.

Gill nets were deployed as close to shore as possible without snagging and were drifted for 1-2 minutes to minimize mortalities. Three east bank sites and three west bank sites were established and used at different times throughout the 1988 and 1990 study period (Figure 2). A random stratified sampling schedule (Scheaffer et al. 1979) was used to sample salmon with gill nets in 1988 and 1990. In 1988, five gill net sets were drifted along each river bank over a two hour sampling period. Each two hour sampling period was randomly selected within a four hour morning (0700-1100), afternoon (1200-1600), and evening (1900-2300) strata. In 1990, three to five gill net sets were drifted along each river bank during a two hour sampling period. Each two hour sampling period was randomly selected within an eight hour night (0000-0800), day (0800-1600), and evening (1600-2400) strata. All fish caught were identified to species, counted, and marked by punching a hole in the caudal fin. Recaptured fish were not used in species composition estimates.

Beach seine sampling sites were established on both the east and west banks within 100 m of the sonar site (Figure 2). Initial beach seining efforts emphasized determining feasibility and deployment methods and usually corresponded with periods of high fish passage.

Scaffold towers (5.5 m) were set up on each side of the river near the primary sonar sites. Tower counts were made from 10 July to 6 September 1988 and from 25 June to 15 September 1990. A set schedule was not establish for tower counts. When weather and lighting conditions permitted, counts were made for 15 minutes. Because of the water depth and clarity, counts were made out to 15 m on the west side out to 32 m on the east side. The tower counts were primarily used in conjunction with gill netting to estimate species composition. Periodically, the tower counts were use to check the sonar calibration.

The minimum sample size used for species composition estimates was 100, based on " = 0.1, and a maximum acceptable error (d) = 0.1 (Thompson 1987). Total salmon escapement estimates were calculated by species, day, and sonar site using a stratified sampling procedure (Scheaffer et al. 1979). The escapement estimate was:

$$\hat{N}_{ijk} = (C_{jk} * \hat{P}_{ijk})$$

Where:

$\hat{N}_{ijk}$ = the estimated number of salmon of species i, on day j which migrate past sonar site k.

C_{jk} = the total number salmon counted by sonar on day j for site k.

$\hat{P}_{ijk}$ = the proportion of salmon species i sampled by gill net, beach seine, or visual count, on day j, for site k.

All captured fish were measured to the nearest cm (mid-eye to fork length) and sexed using external morphological characteristics. To assess sampling biases, differences in mean lengths were compared by capture method (gillnet and seine) using ANOVA (" = 0.05). The sex ratios were compared to a ratio of 1:1 using Chi-square test (" = 0.05).

Salmon Migration Time

The migration time from the river mouth to the sonar site was estimated by graphically comparing commercial fishery catches in Togiak Bay with fluctuations in salmon escapement past the sonar site. The analysis assumed that closures in the fishery would result in increased numbers of fish past the sonar. The migration time between the sonar site and the Department's tower site at Togiak Lake was estimated by comparing migration patterns past each site. The escapement numbers were smoothed to highlight changes in run strength by using a three day moving average of the daily estimate.

RESULTS

Sonar Operation

Sonar counters were operated at two east bank sites and one west bank site in 1987 (Finn 1990). Four east bank sites and two west bank sites we used during 1988 and 1990. East bank site E1 was used during high water levels; east and west bank sites E2 and W2 were used at moderately high water levels; east and west bank sites E3 and W1 were used at moderate to low water flows; and east bank site E4 was used at low water levels. The sonar operated at sites E3 and W1 the majority of time during 1988 and 1990. The counting range on the East side was 61.0 m on the East bank and 30.5 m on the West bank (Figure 3). During the study period, water levels fluctuated 1.8 m in 1988 and 1.5 m in 1990 (Figure 4).

Sonar Calibration

Daily *Q* were maintained within (0.8 - 1.2) 69% of the sample period in 1987 (Finn 1990) compared to 78% of the sample period in 1988 and 77% of the sample period in 1990 (Figure 5).

The *Q* based on tower and oscilloscope counts were estimated concurrently for the range between 0 and 8 m. The estimated Q were not significantly different ($t=0.226$, $df=7$, $P=0.824$).

The chart recorder was set to produce echograms for the area between the transducer face and 4, 8, 20, and 40 m. The estimated Q produced for each distance were not significantly different from each other ($F=2.331,3,32$; $P=0.093$). The data were pooled and compared to Q estimated concurrently using the oscilloscope. The estimated Q were not significantly different ($t=1.325$; $df=35$; $P=0.194$).

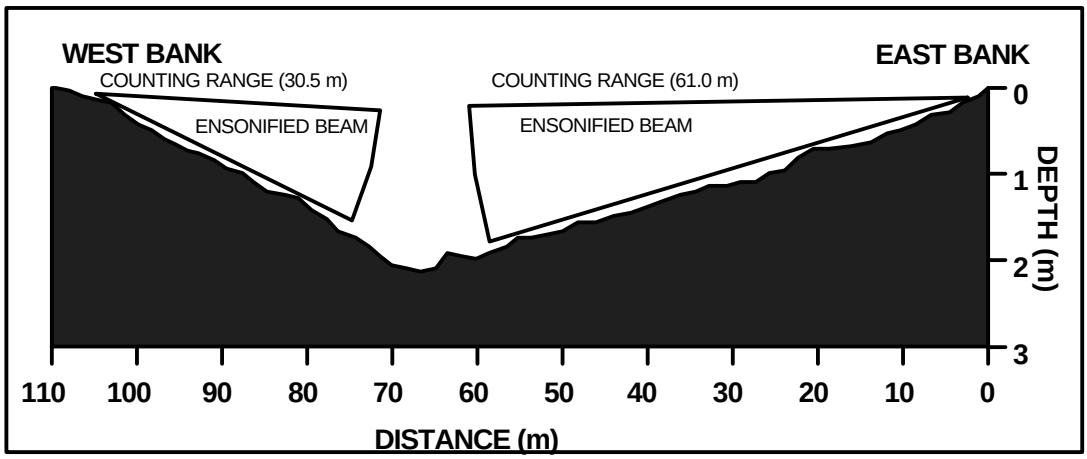

Figure 3.-River channel profile and side-scan sonar maximum counting ranges on the Togiak River, Alaska in 1988 and 1990.

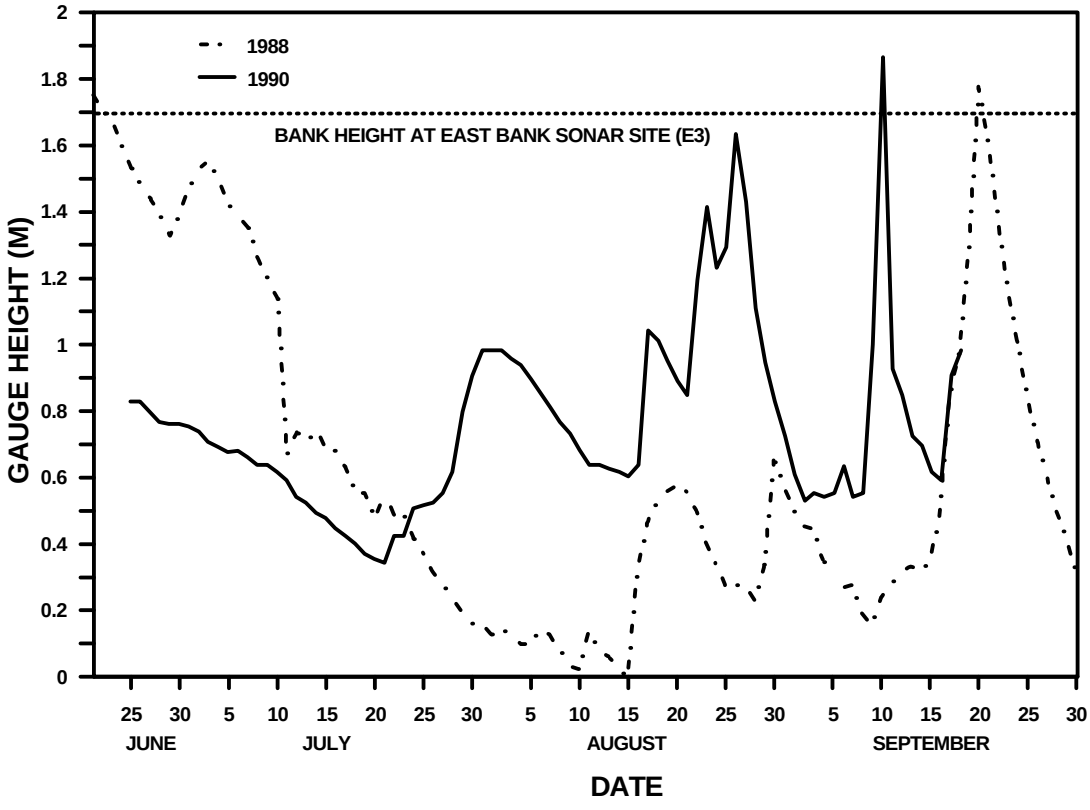

Figure 4.-Staff gauge height (m) during June-September 1988 and 1990 on the Togiak River, Alaska.

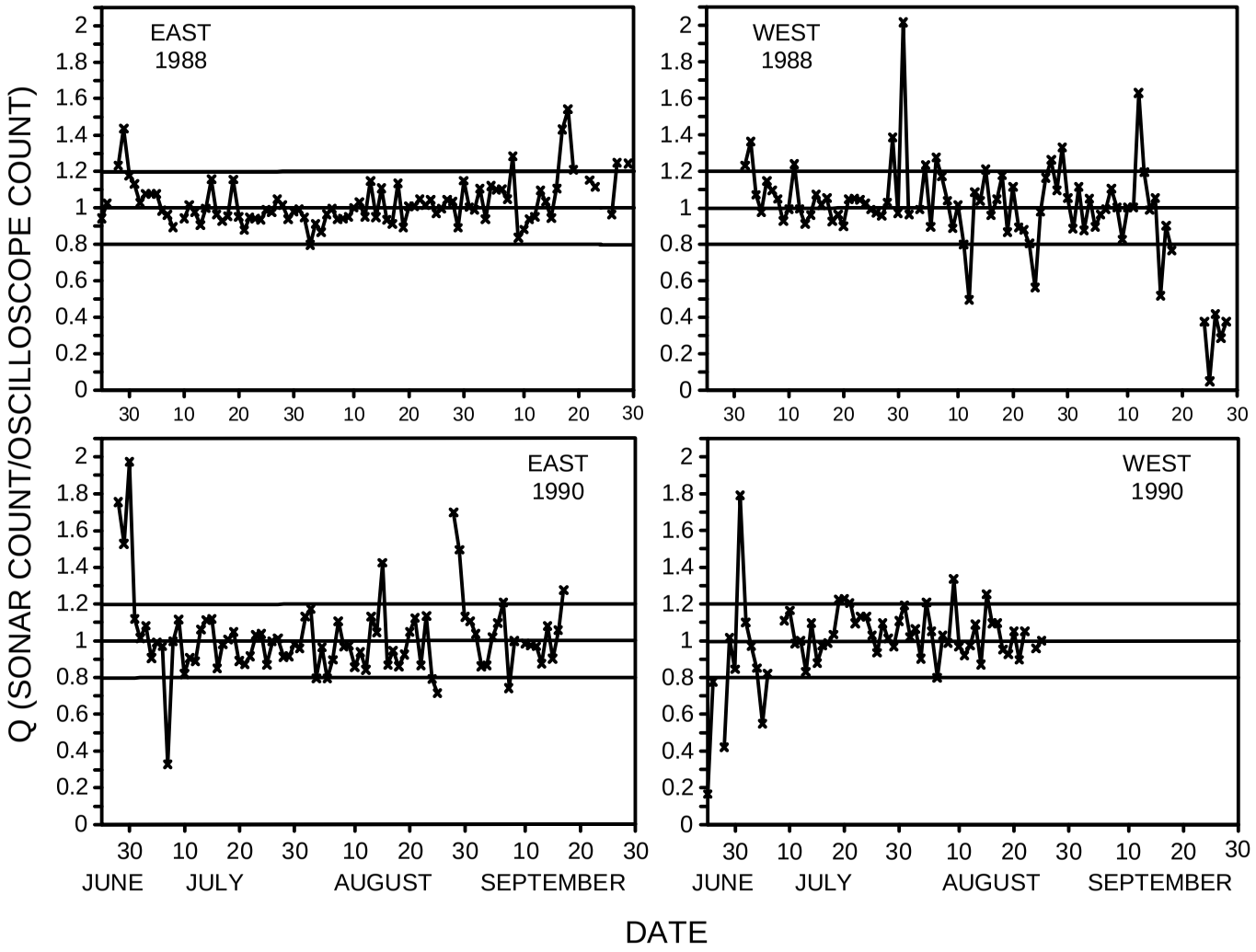

Figure 5.-Mean daily Q for east and west bank sonar counters during June-September 1988 and 1990 on the Togiak River, Alaska.

Sonar Counts

Sonar counters operated for 42 days (12 August-22 September) in 1987 (Finn 1990), 97 days (25 June-30 September) in 1988, and 84 days (25 June-17 September) in 1990. Only counts from the east bank were possible after August 22, 1990 because the west bank sonar broke down. The season salmon escapement estimate was 969,684 in 1988 and 908,590 in 1990 (Table 1). In 1988, the maximum daily salmon escapement estimate was 35,282 on July 11, 1988 (Appendix A) and 29,194 on July 23, 1990 (Appendix B). The majority of salmon passed the sonar sites between late June and early August during 1988 and 1990 (Figure 6). The east bank sonar counter always had higher counts than the west bank counter. In addition, the sonar counts were highest in sectors 1-6 (Figure 7).

Species Apportionment

Sockeye salmon contributed the largest proportion of fish to the total escapement in 1988 (54%) and 1990 (67%) (Table 2). Sockeye salmon were the first to migrate into the Togiak River beginning in mid-June, reaching peak numbers by mid-July, and tapering off in late-August (Figure 8). Other fish such as Dolly Varden and rainbow trout also contributed to the total run size in 1988 (3%) and 1990 (1%). Dolly Varden numbers peaked in late August and early September while rainbow trout were counted periodically over the study period.

Sonar estimates were compared to escapement estimates made by the Department. The sonar escapement estimates were higher than the Department's estimates, especially in 1990 (Table 2). Only comparisons for sockeye salmon escapement were possible because estimates made by the Department for the other species were an index of run strength.

Table 2.-Escapement estimates for chinook, chum, coho, pink and sockeye salmon using sonar and by the Alaska Department of Fish and Game for the Togiak River, Alaska during 1987, 1988, and 1990 (Alaska Department of Fish and Game 1989, 1990, 1991).

	Escapement Estimate[a]					
	1987[b]		1988		1990	
Species	ADFG	Sonar	ADFG	Sonar	ADFG	Sonar
Chinook	-	2,408	-	7,698	-	15,098
Chum	-	46,830	-	246,144	-	134,958
Coho	-	68,428	-	78,589	-	28,290
Pink	-	1,730	-	96,167	-	131,484
Sockeye	278,276	18,002	309,012	512,581	189,122	589,321
Total		137,398		941,179		899,151

[a] ADFG only estimates sockeye salmon escapement into the Togiak River.
[b] The sonar estimates are incomplete except for coho salmon. The sonar was not operational until August 12, 1987.

Table 1.-Monthly total sonar estimate of salmon escapement on the Togiak River, Alaska during August-September 1987 and June-September 1988 and 1990.

	1987			1988			1990		
Date	East	West	Both	East	West	Both	East	West	Both
June	-	-	-	21,094	9,771	30,865	7,695	2,051	9,746
July	-	-	-	307,379	329,282	636,661	304,726	255,765	560,491
August	64,396	32,613	97,009	165,102	79,358	244,460	211,088	106,427	317,515
September	21,487	19,001	40,488	34,781	22,916	57,698	20,837	-	20,837
Total	85,883	51,614	137,497	528,357	441,327	969,684	544,346	364,244	908,590

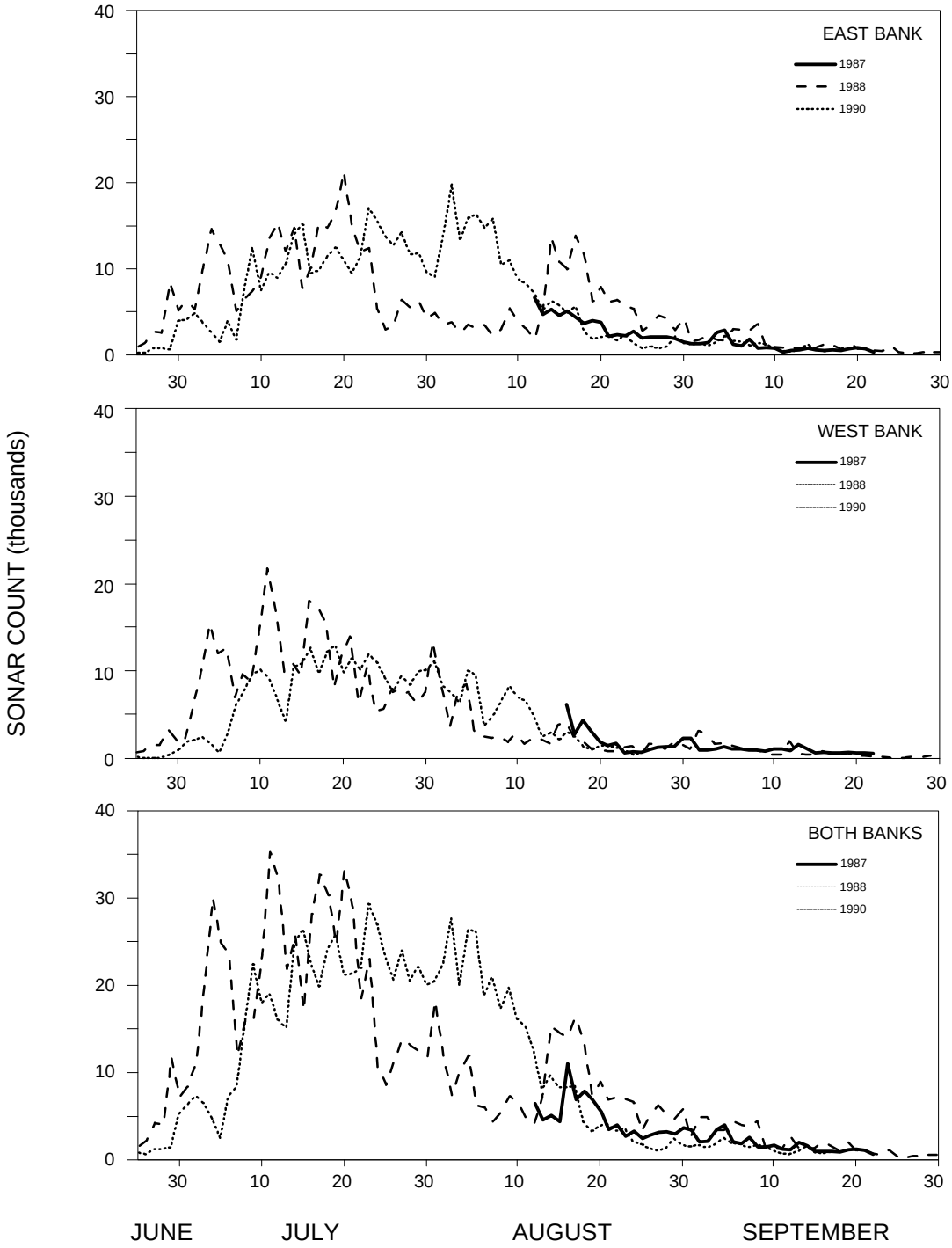

Figure 6.-Daily sonar counts for the east and west banks of the Togiak River, Alaska during June-September 1988 and 1990.

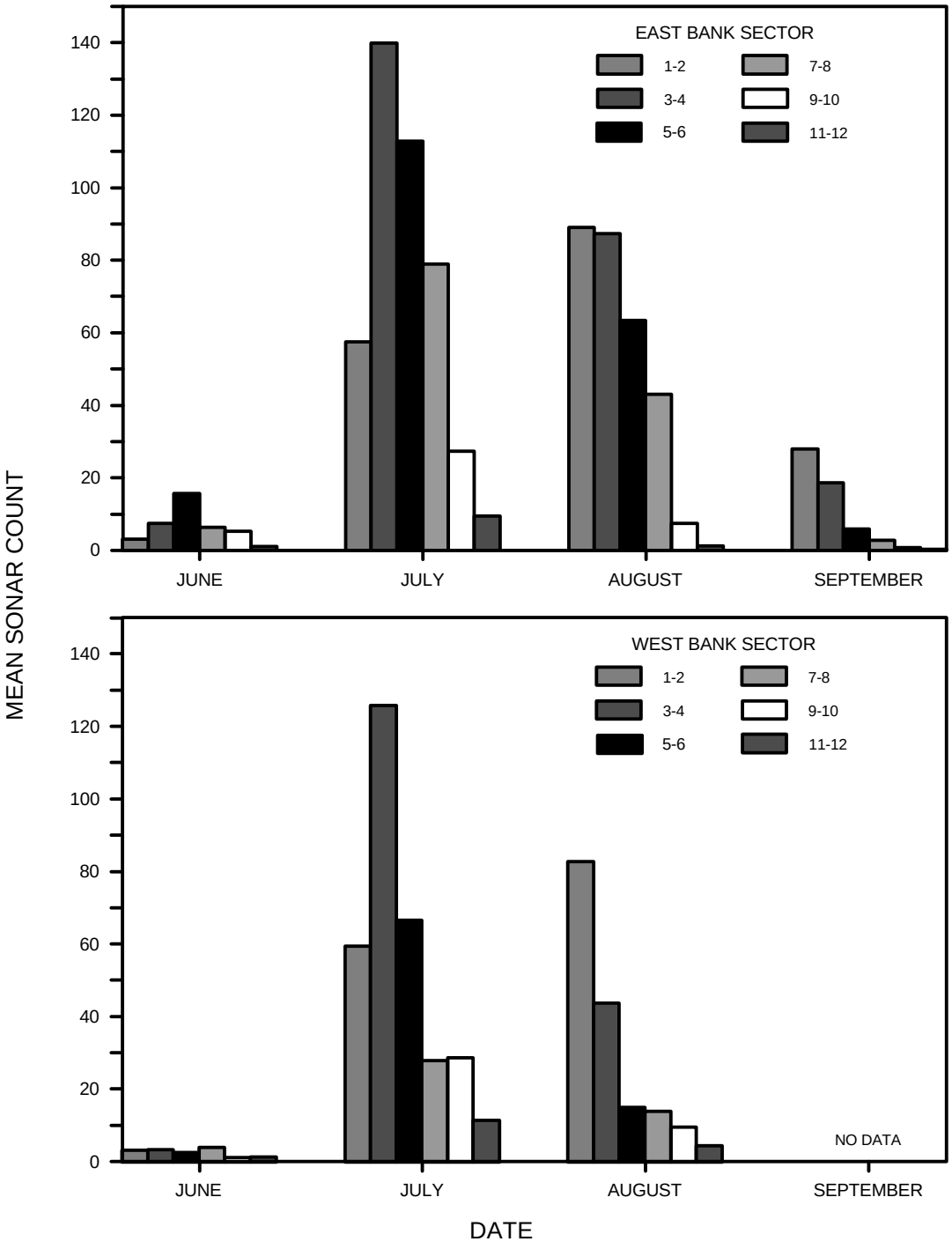

Figure 7.-Sector sonar counts for the east and west banks of the Togiak River, Alaska during June-September 1988 and 1990.

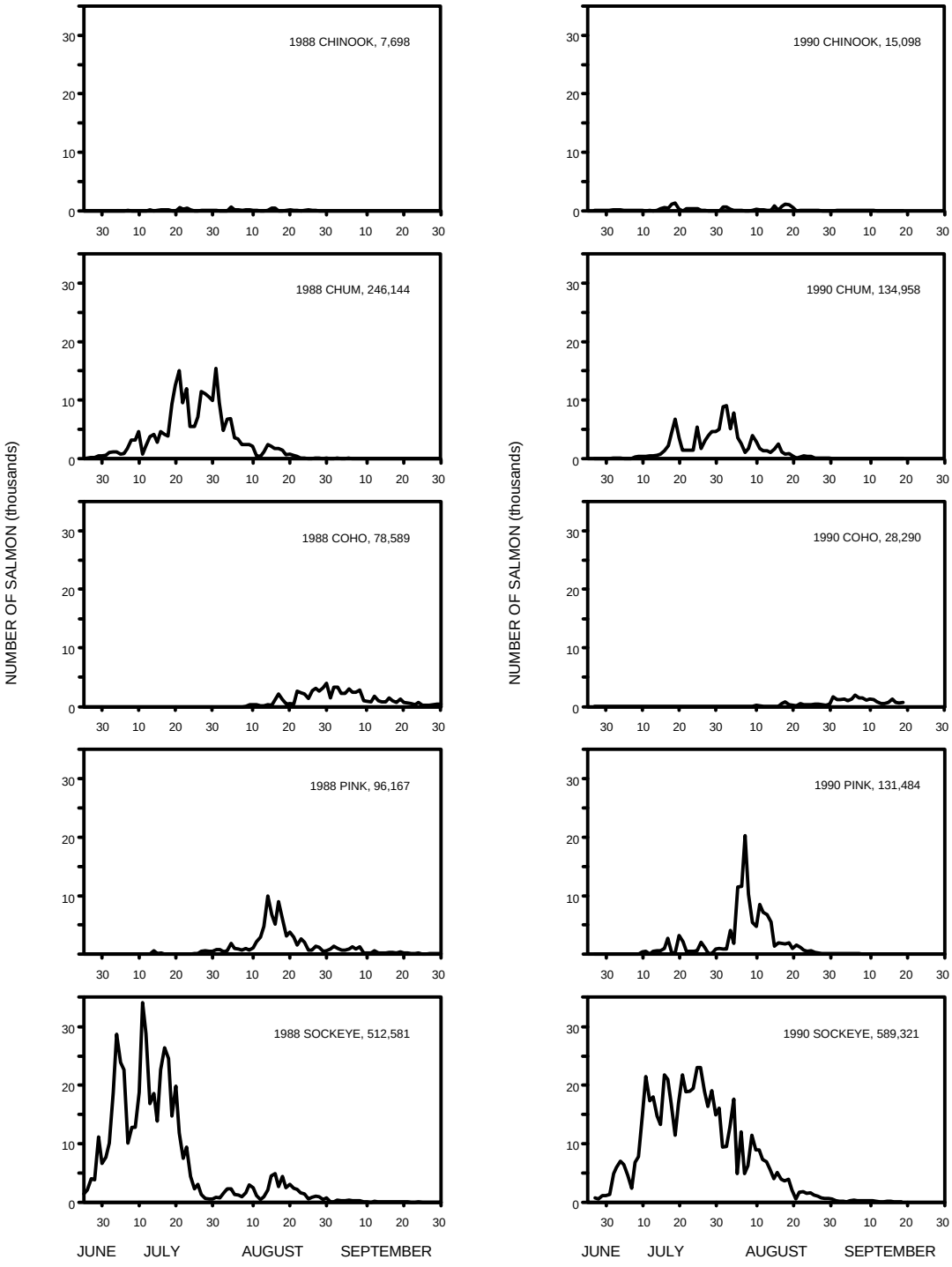

Figure 8.-The estimated number of chinook, chum, coho, pink, and sockeye salmon in the Togiak River, Alaska during June-September 1988 and 1990.

Approximately 17,000 and 10,000 fish were observed from the towers at the sonar site in 1988 and 1990 (Table 3). Approximately 4,000 and 3,000 salmon were caught in gill nets during 1988 and 1990 (Table 4). Sockeye salmon were the most abundant species caught in gill nets. In 1988, pink salmon comprised the most abundant species observed from the tower, while in 1990 sockeye salmon were the most frequently observed species. More chum salmon were caught in gill nets than pink salmon. Conversely, pink salmon were observed at a higher rate than chum salmon from the tower. Chinook salmon were the least frequent species sampled by the gill net and tower. Chinook salmon comprised 0.7 and 2.9% of the total gill net catch and 0.3 and 0.1% of the total tower count in 1988 and 1990.

Gill netting for species apportionment was conducted on most days except when the river was flooding. Tower counts were sporadic because viewing conditions were weather dependent. Weather conditions allowed counts to be conducted 14% of the total available days. Light conditions limited tower counts to between 9 am to noon and 2 pm to 5 pm. All fish could be identified to species until coho salmon began entering the river in August. Coho and fresh sockeye salmon could not be reliably identified to species from the tower. Tower counts were also limited to sonar sectors 1 through 4 because of water depth and clarity.

Mean lengths varied by sampling method (Table 5, Appendix C). The only comparison of gear type that was not significantly different (1988 $t=0.290$, $P=0.77$, $df=467$; 1990 $t=1.195$, $P=0.23$, $df=175$) was for sockeye salmon caught in 12 cm gill net and in the beach seine. Generally, larger fish were caught by the larger mesh gill nets.

Most of the salmon were caught in the 12 and 14 cm gill nets (Table 5). Most of the chinook salmon were caught in the 20 cm gill net. The beach seine success was variable. Very few fish were caught using the beach seine in 1988 while 15% of the total net sample was caught in the beach seine in 1990.

The sex ratios of salmon caught in the gill nets and beach seine were not significantly different from 1:1 except chum and chinook salmon (Table 6, Appendix C). Mostly male chum salmon were caught in gill nets while the sex ratio was not significantly different from 1:1 for chum caught in the beach seine. In 1988, the 20 cm gill net caught mostly female chinook salmon.

Salmon Migration Time

A plot of the daily escapement estimates from the sonar and the Department's counting tower were superimposed (Figure 9). By shifting the sonar counts 3 days later, the run timing is almost identical in 1988 (Figure 10). The pattern was more variable in 1990. Before July 21, shifting the sonar counts 3 days caused the patterns to coincide. After July 21, shifting the sonar counts by 1 to 2 days caused the patterns to coincide.

Table 3.-The number of salmon counted from the east and west bank towers, Togiak River, Togiak National Wildlife Refuge, Alaska, June-September 1988 and 1990.

Date	Days Sampled	No. Cnts	Species							
			Sockeye	Chinook	Chum	Coho	Pink	Brights[a]	Other[b]	Total
East Bank 1988										
12 Jul-31 Jul	19	32	2,904	22	1,716	0	348	0	69	5,059
1 Aug-31 Aug	26	47	251	8	358	0	2,948	549	258	4,372
1 Sep- 6 Sep	6	17	7	1	1	1	112	119	57	298
Total	51	96	3,162	31	2,075	1	3,408	668	384	9,729
West Bank 1988										
10 Jul-31 Jul	18	27	1,846	7	800	0	794	0	49	3,496
1 Aug-31 Aug	22	44	379	5	200	0	2,708	422	13	3,727
1 Sep- 6 Sep	6	11	6	1	0	0	30	21	0	58
Total	46	82	2,231	13	1,000	0	3,532	443	62	7,281
Both Banks 1988										
10 Jul-31 Jul	19	59	4,750	29	2,516	0	1,142	0	118	8,555
1 Aug-31 Aug	26	91	630	13	558	0	5,656	971	271	8,099
1 Sep- 6 Sep	6	28	13	2	1	1	142	140	57	356
Total	51	178	5,393	44	3,075	1	6,940	1,111	446	17,010

Table 3.-continued

Date	Days Sampled	No. Cnts	Species							Total
			Sockeye	Chinook	Chum	Coho	Pink	Brights[a]	Other[b]	
East Bank 1990										
2 Jul-31 Jul	18	50	2,780	6	133	0	189	-	0	3,108
1 Aug-31 Aug	19	43	1,693	1	286	72	1,810	-	35	3,897
1 Sep-15 Sep	10	29	5	0	0	140	5	-	0	150
Total	47	122	4,478	7	419	212	2,004	-	35	7,155
West Bank 1990										
2 Jul-31 Jul	17	18	1,171	4	113	0	102	-	0	1,390
1 Aug-31 Aug	16	39	441	0	232	0	973	-	0	1,646
1 Sep-15 Sep	-	-	-	-	0	0	-	-	-	-
Total	33	57	1,612	4	345	0	1,075	-	0	3,036
Both Banks 1990										
2 Jul-31 Jul	18	68	3,951	10	246	0	291	-	0	4,498
1 Aug-31 Aug	19	82	2,134	1	518	72	2,783	-	35	5,543
1 Sep-15 Sep	10	29	5	0	0	140	5	-	0	150
Total	47	179	6,090	11	764	212	3,079	-	35	10,191

[a]Brights were sockeye and coho salmon that could not be visually distinguished from the tower.
[b]Other fish were composed of Dolly Varden and rainbow trout.

Table 4.-The number of salmon caught during gill netting on the east and west side of the Togiak River, Togiak National Wildlife Refuge, Alaska, June-September 1988 and 1990.

Date	Days Sampled	No. Sets	Species						Total
			Sockeye	Chinook	Chum	Coho	Pink	Other[a]	
East Bank 1988									
27 Jun-30 Jun	4	39	95	0	2	0	0	0	97
1 Jul-31 Jul	19	167	735	5	222	0	12	31	1,005
1 Aug-31 Aug	23	360	131	0	113	218	249	20	731
1 Sep-27 Sep	16	116	17	1	11	544	65	14	652
Total	62	682	978	6	348	762	326	65	2,485
West Bank 1988									
1 Jul-30 Jul	19	122	519	4	291	0	1	22	837
1 Aug-31 Aug	23	306	147	19	207	77	155	41	646
1 Sep-24 Sep	16	26	3	0	0	25	4	2	34
Total	58	454	669	23	498	102	160	65	1,517
Both Banks 1988									
27 Jun-30 Jun	4	39	95	0	2	0	0	0	97
1 Jul-31 Jul	19	289	1,254	9	513	0	13	53	1,842
1 Aug-31 Aug	23	666	278	19	320	295	404	61	1,377
1 Sep- 6 Sep	16	142	20	1	11	569	69	16	686
Total	62	1,136	1,647	29	846	864	486	130	4,002

Table 4.-continued

Date	Days Sampled	Sets	Species						Total
			Sockeye	Chinook	Chum	Coho	Pink	Other[a]	
East Bank 1990									
25 Jun-30 Jun	5	66	6	0	1	0	0	0	7
1 Jul-31 Jul	19	185	357	10	83	0	14	7	471
1 Aug-31 Aug	20	219	358	4	225	121	194	39	941
1 Sep-15 Sep	7	96	5	0	1	73	0	2	81
Total	51	566	726	14	310	194	208	48	1,500
West Bank 1990									
25 Jun-30 Jun	5	72	22	0	2	0	0	0	24
1 Jul-30 Jul	19	188	483	15	193	0	5	3	699
1 Aug-31 Aug	20	220	352	60	204	48	51	43	758
1 Sep-15 Sep	7	97	9	1	0	39	0	2	51
Total	51	577	866	76	399	87	56	48	1,532
Both Banks 1990									
25 Jun-30 Jun	5	138	28	0	3	0	0	0	31
1 Jul-31 Jul	19	373	840	25	276	0	19	10	1,170
1 Aug-31 Aug	20	439	710	64	429	169	245	82	1,699
1 Sep-15 Sep	7	193	14	1	1	112	0	4	132
Total	51	1,143	1,592	90	709	281	264	96	3,032

[a]Other fish were composed of Dolly Varden and rainbow trout.

Table 5.-Mean length, standard deviation, sample size, and percentage of chinook, chum, coho, pink, and sockeye salmon captured in 20 cm, 14 cm, and 12 cm gill nets and in the beach seine in the Togiak River, Alaska during 1988 and 1990.

Gear Type																
	20 cm				14 cm				12 cm				Beach Seine				Total
Species	$\bar{X}$	SD	N	%	$\bar{X}$	SD	N	%	$\bar{X}$	SD	N	%	$\bar{X}$	SD	N	%	N
1988																	
Chinook	888.4	67.2	57	83.3	636.0	-	1	1.5	681.1	194.6	10	14.7			0	0.0	68
Chum	641.4	21.5	21	3.8	626.9	28.5	31	5.6	611.5	31.3	494	90.0	635.3	21.6	3	0.5	549
Coho	557.0	-	1	0.2	607.0	36.3	194	48.3	585.9	45.3	207	51.5			0	0.0	402
Sockeye	610.6	36.6	11	1.9	590.2	30.0	93	16.2	582.3	34.1	447	78.0	582.2	35.0	22	3.8	573
Total			90	5.7			319	20.0			1,158	72.7			25	1.6	1,592
1990																	
Chinook	747.5	167.4	31	47.0	728.8	136.6	11	16.7	773.9	154.0	22	33.3	848.5	30.4	2	3.0	66
Chum	620.9	34.1	39	9.5	601.0	47.4	103	25.1	565.5	42.9	210	51.2	569.2	45.7	58	14.1	410
Coho			0	0.0			0	0.0	585.6	38.6	245	100.0			0	0.0	245
Pink			0	0.0	443.9	23.7	7	3.5	434.2	24.0	124	62.0	418.3	26.8	69	34.5	200
Sockeye	550.2	38.6	19	3.0	559.2	39.7	432	68.8	536.7	41.9	73	11.6	536.1	44.6	104	16.6	628
Total			89	5.8			553	35.7			674	43.5			233	15.0	1,549

Table 6.-Sex ratio (Males:Females) of chinook, chum, coho, pink, and sockeye salmon captured in 20 cm, 14 cm, and 12 cm gill nets and in the beach seine in the Togiak River, Alaska during 1988 and 1990. The (+) indicates the ratios were signicantly different from 1:1 at P>0.05, Df=1.

Species	Gear Type			
	20 cm	14 cm	12 cm	Beach Seine
		1988		
Chinook	1 : 5.3+	1 : 0.0+	1 : 0.7+	0
Chum	1 : 0.0+	1 : 0.1+	1 : 0.2+	1 : 0.5
Coho	0.0 : 1	1 : 1.3	1 : 1.1	0
Sockeye	1 : 0.4	1 : 1.2	1 : 1.4	1 : 1.2
		1990		
Chinook	1 : 0.6	1 : 1.8	1 : 0.6	0.0 : 1
Chum	1 : 0.0+	1 : 0.3+	1 : 0.4+	1 : 0.8
Coho	0	0	1 : 0.9	0
Pink	0	1 : 0.0+	1 : 1.1	1 : 1.1
Sockeye	1 : 1.7	1 : 0.9	1 : 0.8	1 : 1.4

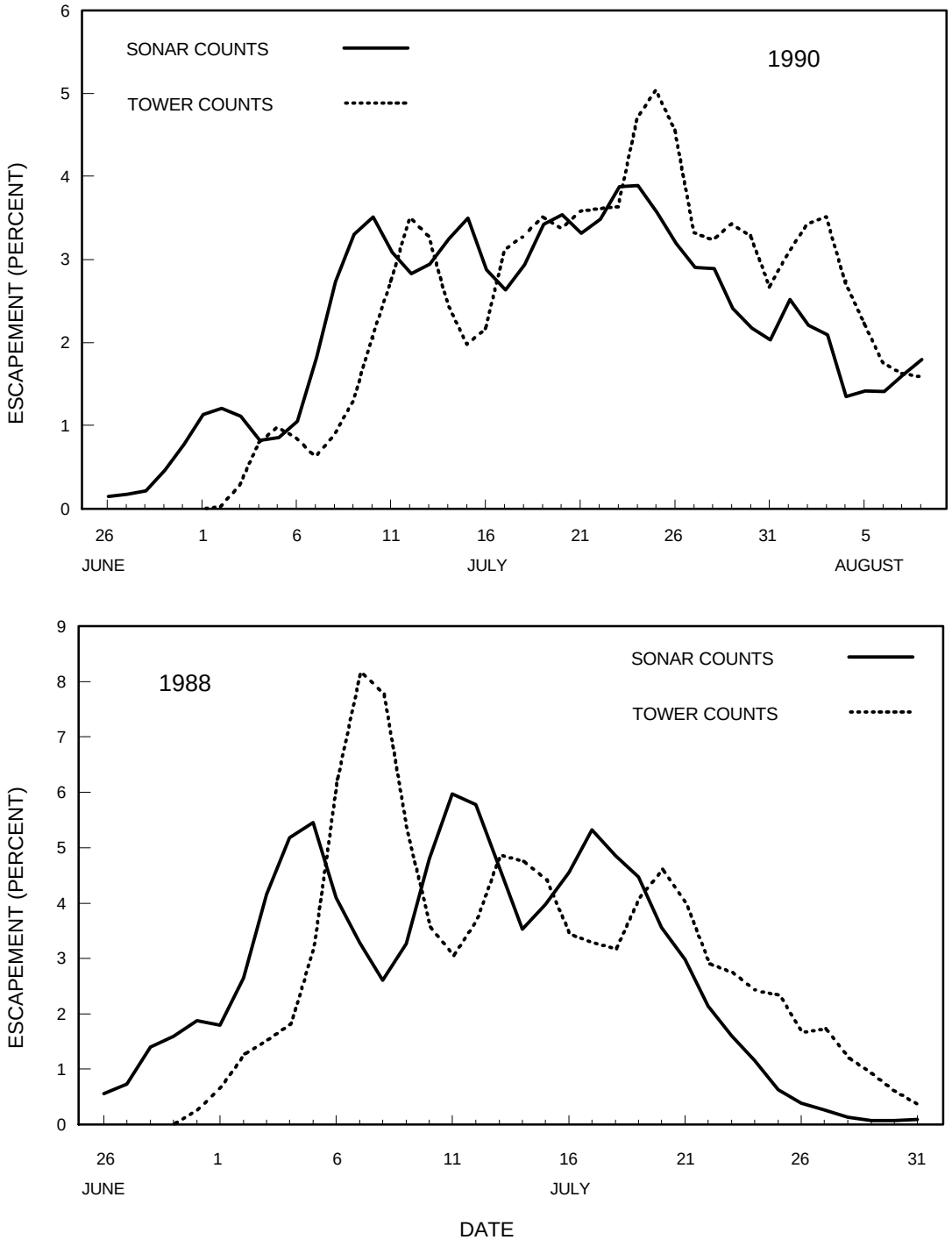

Figure 9.-The estimated salmon escapement (3 day moving average) past the sonar site (Rkm 30) and past the counting tower (Rkm 97) in the Togiak River, Alaska during 1988 and 1990.

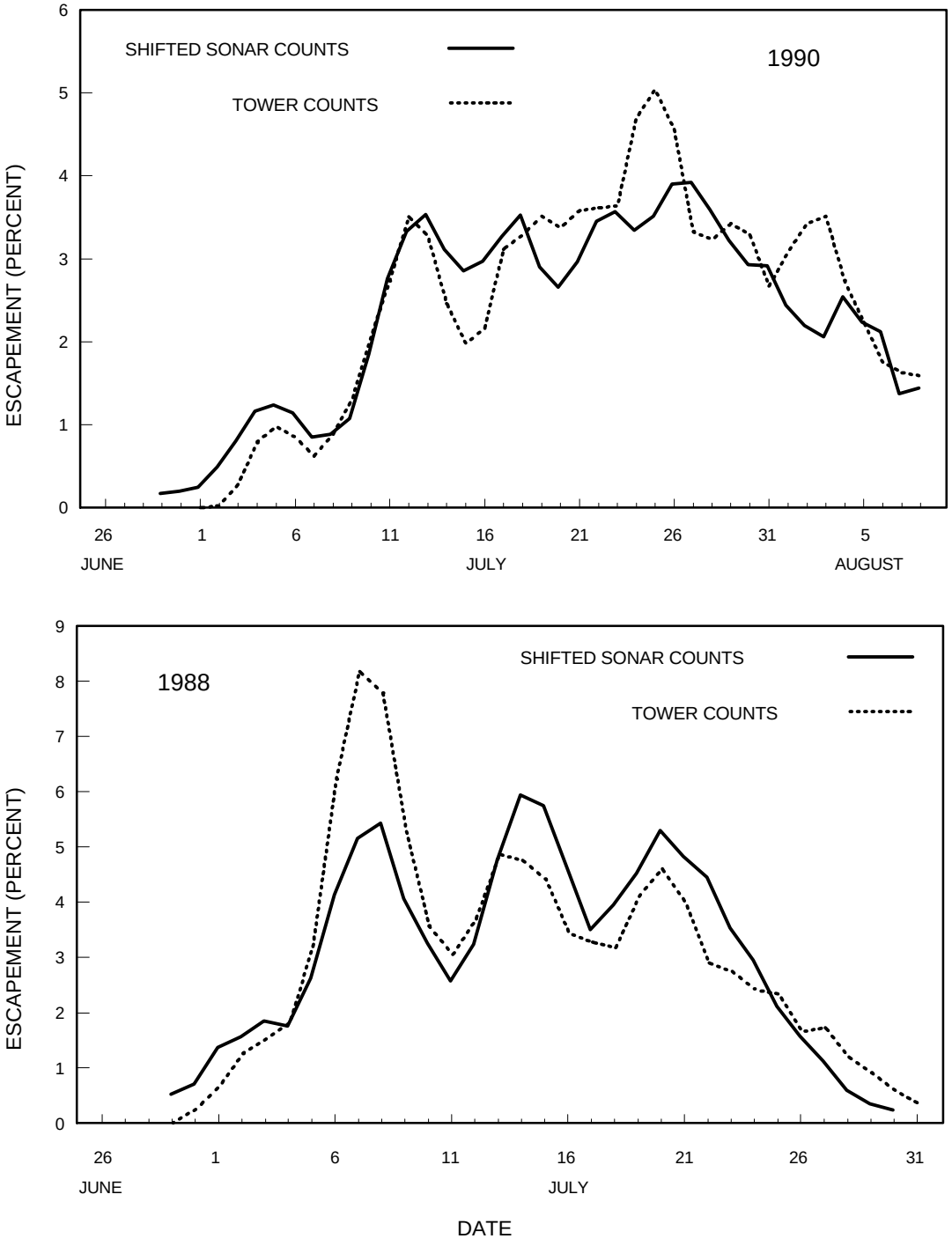

Figure 10.-The timing of the estimated salmon escapement (3 day moving average) past the sonar site (Rkm 30) shifted 3 days and the actual salmon run timing past counting tower (Rkm 97) in the Togiak River, Alaska during 1988 and 1990.

The patterns of catches in the commercial fishery and escapement past the sonar site were used to estimate migration time from the river mouth to the sonar site (Figure 11). In July, shifting the commercial catch dates two days fit the escapement pattern best. In August, shifting the commercial catch four days fit the escapement pattern best.

DISCUSSION

Escapement Estimates

The overall accuracy of the sonar estimates was difficult to measure. Comparisons between sonar and the Department's escapement estimates were only possible for sockeye salmon. Escapement estimates for other species were an index and not comparable to the sonar counts.

Theoretically, the sonar counts should underestimate the total escapement. The sonar site was above two Togiak River tributaries and will never account for 100% of the salmon escapement. Other methods will need to be used (aerial survey or weirs) in addition to the sonar, to account for the total escapement. Also, the sonar was not capable of covering the entire river width and some fish migrated beyond the sonar detection range. However, the majority of salmon appear to migrate near shore. No adjustment of the sonar count was made for fish moving beyond the sonar's counting range. System shutdowns caused by debris or boat traffic should also cause the sonar count to be an underestimate. No adjustment to the sonar count was attempted during these shutdowns as it was assumed the number of fish migrating during the shutdown was relatively minor. The counts were adjusted if the shutdown became protracted.

Instead of underestimating the salmon run size, the sonar appeared to over-estimate escapement. The 1988 and 1990 sockeye salmon sonar escapement estimates were two to three times higher than the Department's estimates. The source of error could be produced by either over-estimating the total number of targets counted by the sonar or by incorrectly estimating species composition of the run.

The sonar beam adjustment and calibration could cause the total number of targets to be over-estimated. However, based on the oscilloscope picture and the artificial fish, the sonar beam was adjusted correctly. In addition, daily Q stayed within acceptable calibration levels the majority of sample periods. On those occasions when Q exceeded the acceptable threshold, daily sonar counts were adjusted. Tower counts provided the most direct calibration of the sonar data and were in agreement with oscilloscope counts the majority of time. Unfortunately, poor weather and limited acceptable lighting conditions prevented using tower counts as a consistent calibration method. The tower counts were also limited to the near shore sectors.

Calibration of the Bendix sonar became more difficult as the population shifted from primarily a single species to multi-species migration. Each species had varying seasonal, diel, and spatial migration patterns. When properly calibrated to count higher concentrations of medium-sized

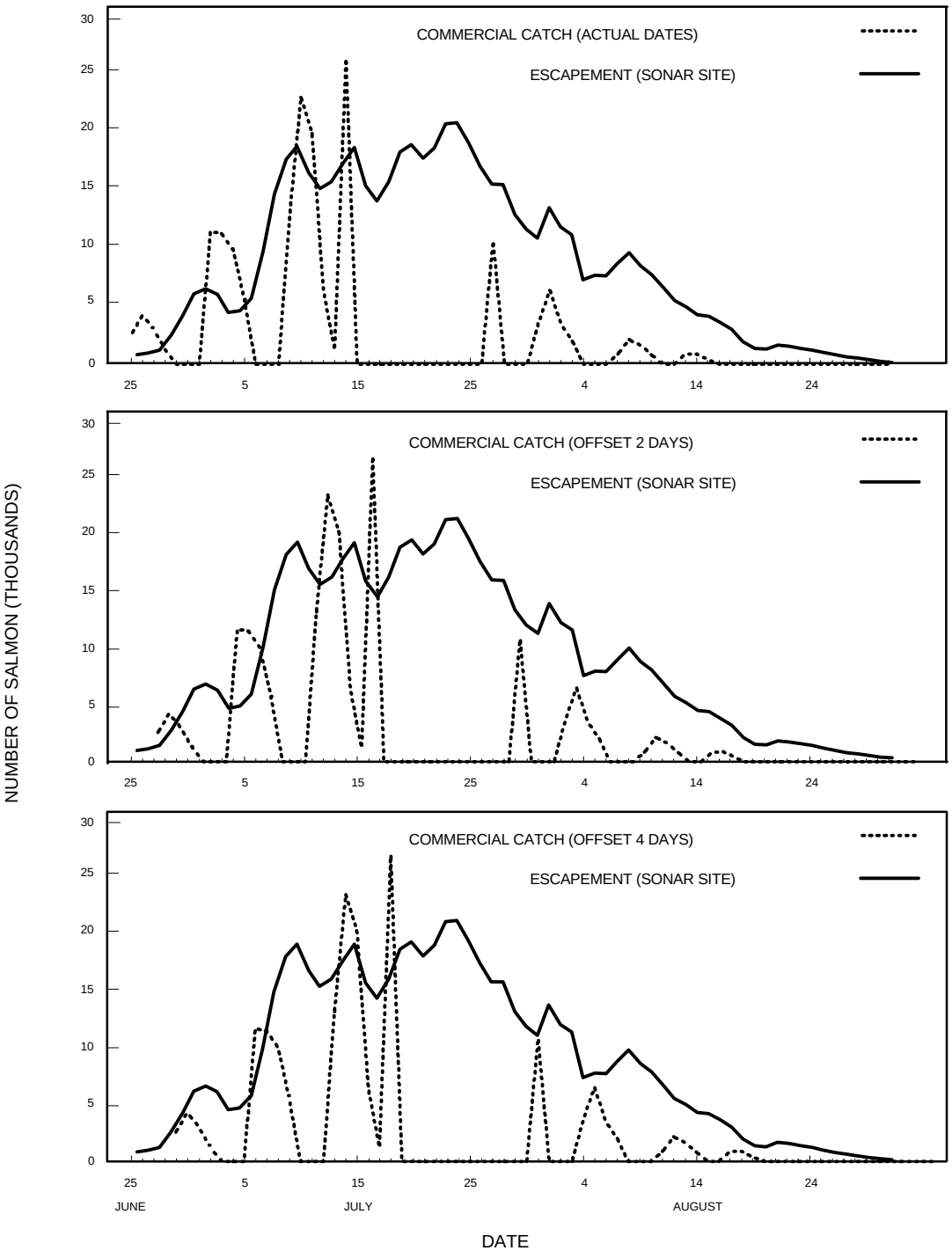

Figure 11.-The number of salmon harvested by the commercial fishery in Togiak Bay by actual capture date, the date offset by 2 days, and the date offset by 4 days superimposed over the estimated salmon escapement (3 day moving average) past the sonar site (Rkm 30) in the Togiak River, Alaska during 1990.

coho and sockeye salmon, the sonar counters under-counted the smaller, faster pink and sockeye salmon, and over-counted the larger, slower chinook and chum salmon. To assure accurate escapement estimates, the sonar counters should be calibrated at least every 4 hours to compensate for varying fish size and swimming speed.

Most of the calibration in the study relied on comparisons between oscilloscope and sonar counts. The oscilloscope provided an instantaneous count that could then be compared with the sonar count. However, calibrating the counter based on the oscilloscope required considerable experience and once the count was made by the operator, no verification of the count could be made. To reduce operator error and provide a permanent data record of the calibration, an echogram was produced using a chart recorder in 1990. The echogram was found to provide the same Q as the oscilloscope and the tower. In addition, it provided a permanent paper record that could be interpreted by several people. Future operations should use the echogram as the primary calibration tool and use the oscilloscope to verify and backup the chart recorder.

External factors probably contributed the majority of error to total escapement estimates. Debris, bubbles from outboard motor cavitation, and hard rain inflated total counts. It was not unusual to observe the sonar counter recording 50-100 extra counts, within a few minutes, as debris or boat traffic went through the sonar beam. On several occasions during very hard rain, the counters recorded hundreds of false counts. Shutting down sonar operations or discarding perceived false count data interfered with normal sonar counting. If many fish were migrating past the sonar counter, the subtle differences in beginning and ending false count episodes were difficult to detect. No adjustment to the data were made in these circumstances. The counter was simply shut off for a short time and any fish that passed during that period were not counted. If the period of disturbance was prolonged, the count was discarded and the missing data were interpolated.

In addition to physical factors, milling behavior of adult salmon around the ensonified sample area caused over counting. Some fish were observed from the counting towers maintaining position within the sonar beam and running up many false counts. Milling fish could be forced to move, but they probably returned during periods when detection by tower observations were not possible. Other than direct observation, no other adjustments to the data were possible. As long as visual observation were possible, false counts caused by milling fish could be deducted from the daily sonar count. Inconsistent tower counts caused by poor light and turbid conditions made the use of this accounting method unreliable.

Another behavioral factor caused an irregularity during 1990 which probably contributed to a severe over-estimate of total escapement. During mid-July, the sonar and oscilloscope counts were double those of the tower count. Upon further inspection, numerous juvenile salmonids were discovered swimming around the transducer face. Migrating juvenile fish would not normally register on the sonar counter, however, by maintaining their position directly in front of and around the

transducer face, they were counted as adult fish. At that time, the water level was low and the transducer face and tripod provided water velocity breaks and cover for juvenile fish. Moving the transducer further from shore into faster current eliminated the over counting. The number of erroneous daily sonar counts considered acceptable is unknown.

Despite milling behavior and physical factors, estimating total target number appears to be possible. At the end of the three year project, additional research was needed before sonar could be employed to estimate salmon run strength. With knowledge and experience, some problems associated with sonar operation may be easy to correct while others may always cause the accuracy to be questioned. Recent improvements in sonar equipment for counting fish in the riverine environment may help to more reliably estimate total escapement.

Species apportionment is a separate and probably greater problem than sonar estimates of total run size. Species apportionment of the daily sonar count was dependent upon random sampling of the fish population. For various reasons, the tower counts, gill netting, and beach seining probably violated the assumptions of random sampling.

The large sample size from tower counts primarily influenced species apportionment. However, tower counts were limited to near shore areas and to periods of adequate visibility. Tower counts were only conducted during mid-day because of lighting conditions. Gill net samples showed diurnal variations in species composition. Using tower counts from mid-day to drive species composition estimates for the entire day may not be appropriate. Tower counts were also limited by turbidity and poor surface conditions during rain and wind events. During the early and late season, water clarity prevented reliable tower counts. The overall bias of the tower counts is unknown.

Very few chinook salmon were observed from the tower. Observations by the sampling crew noted that chinook salmon migrate near the middle of the river well beyond reliable tower counting range. Chinook salmon comprised a smaller proportion of the total tower sample than the total gill net sample. With tower counts primarily influencing species apportionment, chinook salmon were probably underestimated.

Differences in sex ratios revealed that chum salmon may not have been representatively sampled during the three year study. During gill net sampling efforts, more male chum salmon were captured than females. Breeding males develop a pronounced hooked kype, gaping mouth, and large teeth which increased their vulnerability to entanglement. On the Chandalar River, Daum (1991) found that gill net samples produced a male to female sex ratio of 1.0:0.5 compared to a sex ratio of 1.0:1.0 for carcass samples. Catching a disproportionate number of male chum salmon would cause other species to be underestimated.

Other biases were also evident with gill nets. The gill net mesh size influenced the size and number of fish caught. The different gill nets were more efficient at catching selected species and did not sample the

run in proportion to the run strength. The validity of species apportionment based on gill net catches could not be judged.

In addition to gill nets, a beach seine was used to sample salmon populations. The beach seine worked well on the east bank, but not along the west bank, where bottom contours, large cobble, and boulders made seining difficult. In general, the beach seine was less efficient than gill nets but may not be as biased. Chum salmon sexes were caught in equal proportions. Because chinook salmon migrate up the middle of the river, they may not be susceptible to capture in the beach seine.

Because of the overlapped run timing of salmon entering the river, determining species composition appears the most difficult aspect of estimating escapement. The Department has used gill nets to estimate species composition on the Nushagak River and concluded that gill netting adequately describes species composition (Woolington and Bue 1989). However, with the biases identified in this study, additional verification of gill net catches are needed on the Togiak River. Gill nets may be a viable tool for species apportionment but the mesh size should not be selected based on its effectiveness for a particular species. Instead, the gill net web size should be evenly spaced intervals between 10 and 20 cm stretch mesh. We recommend that other methods to estimate species composition also be explored. A possible alternative would be a larger beach seine.

Salmon Migration Time

The sonar location at Rkm 30 could provide salmon escapement estimates within 2 to 4 days of the fishery. Any further decrease in lag time, however, would require moving the sonar operations downriver into less desirable braided portions of the river and would require doubling equipment and crew if a suitable operational site can be found. Moving to a lower river site may add complicating factors such as the tidal influence on fish behavior.

Approximately 3 days are needed for fish to pass from the sonar site to Togiak Lake and approximately 5 to 7 days are needed for the fish to migrate from the river mouth to Togiak Lake. Brannian (1982) estimated that sockeye salmon reach the Department counting tower (Rkm 97) 10-14 days after the fish enter the river. The reason for the difference in the two estimates is unclear. The relationship of run timing variation (maxima and minima) between the tower counts and the sonar are very strong, especially in 1988. The relationship between the commercial opening in Togiak Bay and escapement past the sonar site is less definite. However, observations by the sonar monitoring crew estimated a lag period of 3 days between a commercial fishery closure and an increase in escapement past the sonar site. The graphical interpretation of 2 to 4 days support the monitoring crew's estimate.

Conclusions

Sonar is an expensive tool requiring considerable technical expertise to operate. With five salmon species migrating up the Togiak river, accurate escapement estimates for each species may be impossible without

committing considerably more resources to the project. Before sonar is used for salmon management on the Togiak River, species apportionment bias needs to be solved. Provided river morphology has not changed since this project was complete, using sonar for fishery management probably needs three to five additional field seasons to develop with the understanding that sonar may eventually prove unfeasible on the Togiak River.

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APPENDIX A

Appendix A1.-Adjusted daily sonar count and species composition on the east bank of the Togiak River, Alaska during June-September 1988.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	908	908	0	0	0	0	0
06/26	1,415	1,415	0	0	0	0	0
06/27	2,680	2,680	0	0	0	0	0
06/28	2,565	2,565	0	0	0	0	0
06/29	8,409	8,409	0	0	0	0	0
06/30	5,118	4,841	0	277	0	0	0
07/01	6,331	6,030	0	301	0	0	0
07/02	5,248	4,771	0	477	0	0	0
07/03	10,053	9,681	0	372	0	0	0
07/04	14,612	13,727	0	886	0	0	0
07/05	12,825	12,228	0	596	0	0	0
07/06	10,979	10,810	0	169	0	0	0
07/07	5,034	4,937	0	97	0	0	0
07/08	6,459	5,980	0	478	0	0	0
07/09	7,342	6,798	0	544	0	0	0
07/10	9,051	8,381	0	670	0	0	0
07/11	13,545	12,900	0	645	0	0	0
07/12	15,328	14,834	0	0	0	0	494
07/13	11,967	7,793	0	3,618	0	0	557
07/14	14,769	10,667	0	2,051	0	821	1,231
07/15	7,760	6,518	155	931	0	155	0
07/16	10,051	8,443	201	1,206	0	201	0
07/17	15,201	12,769	304	608	0	0	1,520
07/18	14,740	12,381	295	590	0	0	1,474
07/19	16,666	13,332	0	2,976	0	0	357
07/20	21,218	16,974	0	3,789	0	0	455
07/21	15,020	7,897	465	5,729	0	0	929
07/22	11,974	6,295	370	4,567	0	0	741
07/23	12,420	6,530	384	4,737	0	0	768
07/24	5,355	2,816	166	2,043	0	0	331
07/25	2,932	1,595	0	1,080	0	51	206
07/26	3,331	1,812	0	1,227	0	58	234
07/27	6,410	975	0	4,737	0	418	279
07/28	5,512	349	0	4,465	0	349	349
07/29	6,241	395	0	5,056	0	395	395
07/30	4,162	263	0	3,372	0	263	263
07/31	4,846	307	0	3,926	0	307	307
08/01	3,473	316	0	2,561	0	421	175
08/02	3,773	1,217	0	2,069	0	365	122
08/03	2,500	807	0	1,371	0	242	81
08/04	3,477	1,159	0	1,159	0	1,159	0
08/05	3,133	1,044	0	949	0	1,044	95
08/06	3,450	1,150	0	1,045	0	1,150	105
08/07	2,082	694	0	631	0	694	63
08/08	2,967	1,127	0	653	0	1,127	59
08/09	5,378	2,069	0	2,207	138	827	138

Appendix A1.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
08/10	3,823	1,330	0	1,496	83	831	83
08/11	3,062	340	0	454	227	1,814	227
08/12	1,784	191	0	255	127	1,083	127
08/13	5,109	414	0	1,519	276	2,624	276
08/14	13,578	1,101	0	4,037	734	6,972	734
08/15	10,800	2,531	0	2,363	0	5,906	0
08/16	9,932	1,655	0	1,931	1,380	4,690	276
08/17	13,829	1,133	0	1,587	1,814	9,068	227
08/18	11,626	3,033	0	1,011	758	6,571	253
08/19	6,202	1,691	0	451	451	3,157	451
08/20	7,913	2,158	0	575	575	4,028	575
08/21	6,117	1,668	0	445	445	3,114	445
08/22	6,370	1,416	0	0	4,483	236	236
08/23	5,773	902	0	180	2,345	2,345	0
08/24	5,276	879	0	220	2,418	1,649	110
08/25	2,748	358	0	119	1,792	478	0
08/26	3,491	304	0	152	2,277	455	304
08/27	4,552	705	0	192	2,372	1,218	64
08/28	4,236	656	0	179	2,207	1,134	60
08/29	2,859	102	0	0	2,348	306	102
08/30	4,248	89	0	89	3,098	797	177
08/31	1,543	66	0	0	1,084	361	33
09/01	1,783	17	17	35	1,346	367	0
09/02	2,222	106	0	106	1,772	212	26
09/03	1,741	83	0	83	1,389	166	21
09/04	1,656	79	0	79	1,321	158	20
09/05	2,982	142	0	142	2,378	284	35
09/06	2,845	0	0	0	2,149	632	63
09/07	2,808	134	0	67	2,273	334	0
09/08	3,605	0	0	0	3,051	555	0
09/09	710	11	0	0	612	76	11
09/10	878	14	0	0	756	95	14
09/11	794	12	0	0	684	86	12
09/12	725	0	0	54	671	0	0
09/13	854	0	0	0	831	24	0
09/14	831	44	0	0	743	44	0
09/15	822	46	0	30	639	91	15
09/16	1,213	23	0	0	1,166	0	23
09/17	1,067	65	0	0	938	32	32
09/18	639	39	0	0	562	19	19
09/19	1,461	89	0	0	1,284	44	44
09/20	692	42	0	0	608	21	21
09/21	706	43	0	0	620	21	21
09/22	473	27	0	0	392	9	45
09/23	434	22	0	0	326	0	87
09/24	1,074	49	0	0	806	0	220
09/25	345	12	0	0	259	0	74
09/26	219	6	0	0	169	0	44
09/27	208	0	0	0	176	0	33

Appendix A1.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
09/28	315	0	0	0	266	0	49
09/29	334	0	0	0	282	0	52
09/30	346	0	0	0	292	0	54
Total	528,357	283,413	2,357	92,717	60,192	72,157	17,522

Appendix A2.-Adjusted daily sonar count and species composition on the west bank of the Togiak River, Alaska during June-September 1988.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	594	535	0	59	0	0	0
06/26	813	732	0	81	0	0	0
06/27	1,540	1,386	0	154	0	0	0
06/28	1,474	1,327	0	147	0	0	0
06/29	3,280	2,952	0	328	0	0	0
06/30	2,070	1,863	0	207	0	0	0
07/01	2,043	1,839	0	204	0	0	0
07/02	5,976	5,378	0	598	0	0	0
07/03	9,845	8,861	0	985	0	0	0
07/04	15,339	14,974	0	365	0	0	0
07/05	11,976	11,976	0	0	0	0	0
07/06	12,559	11,617	0	942	0	0	0
07/07	6,967	4,877	139	1,951	0	0	0
07/08	9,617	7,012	0	2,605	0	0	0
07/09	8,695	6,340	0	2,355	0	0	0
07/10	14,404	10,503	0	3,901	0	0	0
07/11	21,737	21,254	0	0	0	0	483
07/12	16,726	14,479	0	1,747	0	0	499
07/13	9,884	8,449	159	797	0	0	478
07/14	10,976	7,913	0	2,042	0	0	1,021
07/15	9,429	7,351	0	1,918	0	0	160
07/16	18,007	14,039	0	3,662	0	0	305
07/17	17,448	13,604	0	3,549	0	0	296
07/18	15,620	12,178	0	3,177	0	0	265
07/19	8,121	2,780	0	5,121	0	0	219
07/20	12,045	4,124	0	7,596	0	0	326
07/21	13,919	3,977	153	9,330	0	0	459
07/22	6,402	1,829	70	4,291	0	0	211
07/23	10,585	3,024	116	7,095	0	0	349
07/24	5,292	1,512	58	3,548	0	0	174
07/25	5,644	376	0	4,741	0	75	452
07/26	7,967	531	0	6,692	0	106	637
07/27	7,504	0	259	7,245	0	0	0

Appendix A2.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
07/28	7,522	0	259	7,263	0	0	0
07/29	6,241	0	215	6,026	0	0	0
07/30	7,529	0	260	7,270	0	0	0
07/31	13,263	0	457	12,805	0	0	0
08/01	8,422	298	0	7,304	0	149	671
08/02	3,608	589	0	2,651	0	147	221
08/03	7,777	1,270	0	5,714	0	317	476
08/04	8,478	807	807	6,258	0	404	202
08/05	3,135	440	220	2,255	0	165	55
08/06	2,534	356	178	1,822	0	133	44
08/07	2,311	324	162	1,662	0	122	41
08/08	2,564	584	162	1,493	65	130	130
08/09	1,872	839	129	452	129	65	258
08/10	2,837	1,150	153	690	230	307	307
08/11	1,630	598	109	163	109	543	109
08/12	2,331	282	0	141	0	1,907	0
08/13	2,163	372	34	169	0	1,588	0
08/14	1,676	288	26	131	0	1,231	0
08/15	3,785	1,500	286	214	143	1,428	214
08/16	4,143	1,792	224	392	224	1,288	224
08/17	2,491	740	0	269	337	942	202
08/18	2,025	760	0	253	217	687	109
08/19	1,125	543	78	155	39	310	0
08/20	1,020	493	70	141	35	281	0
08/21	790	382	55	109	27	218	0
08/22	771	276	29	73	145	247	0
08/23	1,199	339	0	26	339	443	52
08/24	1,402	386	70	0	245	456	245
08/25	481	101	51	0	139	114	76
08/26	1,622	344	98	0	737	246	197
08/27	1,699	360	103	0	772	257	206
08/28	1,048	222	64	0	477	159	127
08/29	1,822	347	87	43	911	217	217
08/30	1,560	439	0	49	975	0	98
08/31	1,035	94	0	0	377	565	0
09/01	3,148	215	0	0	1,502	1,431	0
09/02	2,684	316	0	0	1,263	1,105	0
09/03	1,671	197	0	0	787	688	0
09/04	1,721	202	0	0	810	709	0
09/05	1,491	175	0	0	701	614	0
09/06	1,168	137	0	0	550	481	0
09/07	965	90	0	0	528	332	15
09/08	847	78	0	0	469	287	13
09/09	652	60	0	0	361	221	10
09/10	411	38	0	0	227	139	6
09/11	410	38	0	0	227	139	6
09/12	1,979	183	0	0	1,096	670	30
09/13	535	49	0	0	296	181	8
09/14	379	35	0	0	210	128	6

Appendix A2.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
09/15	473	44	0	0	262	160	7
09/16	805	74	0	0	446	272	12
09/17	504	46	0	0	279	170	8
09/18	419	39	0	0	232	142	6
09/19	539	50	0	0	298	182	8
09/20	388	36	0	0	215	131	6
09/21	268	25	0	0	148	91	4
09/22	214	20	0	0	118	72	3
09/23	155	14	0	0	86	53	2
09/24	83	8	0	0	46	28	1
09/25	27	2	0	0	15	9	0
09/26	78	7	0	0	44	26	1
09/27	215	20	0	0	120	72	3
09/28	162	15	0	0	91	54	2
09/29	270	25	0	0	151	90	4
09/30	257	23	0	0	144	86	4
Total	441,327	229,168	5,341	153,427	18,397	24,010	10,983

Appendix A3.-Adjusted daily sonar count and species composition on both banks of the Togiak River, Alaska during June-September 1988.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	1,502	1,442	0	59	0	0	0
06/26	2,228	2,147	0	81	0	0	0
06/27	4,220	4,066	0	154	0	0	0
06/28	4,039	3,892	0	147	0	0	0
06/29	11,689	11,361	0	328	0	0	0
06/30	7,188	6,704	0	484	0	0	0
07/01	8,374	7,869	0	506	0	0	0
07/02	11,223	10,149	0	1075	0	0	0
07/03	19,898	18,542	0	1357	0	0	0
07/04	29,951	28,700	0	1251	0	0	0
07/05	24,801	24,204	0	596	0	0	0
07/06	23,538	22,427	0	1111	0	0	0
07/07	12,001	9,814	139	2048	0	0	0
07/08	16,075	12,992	0	3083	0	0	0
07/09	16,037	13,138	0	2899	0	0	0
07/10	23,455	18,884	0	4572	0	0	0
07/11	35,282	34,154	0	645	0	0	483
07/12	32,054	29,312	0	1747	0	0	994
07/13	21,851	16,242	159	4415	0	0	1,035
07/14	25,745	18,579	0	4093	0	821	2,252

Appendix A3.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
07/15	17,189	13,869	155	2,849	0	155	160
07/16	28,058	22,482	201	4,869	0	201	305
07/17	32,649	26,372	304	4,157	0	0	1,816
07/18	30,360	24,560	295	3,767	0	0	1,739
07/19	24,787	16,113	0	8,097	0	0	577
07/20	33,263	21,098	0	11,385	0	0	780
07/21	28,938	11,874	617	15,059	0	0	1,388
07/22	18,376	8,125	441	8,859	0	0	952
07/23	23,005	9,554	500	11,833	0	0	1,117
07/24	10,648	4,328	224	5,590	0	0	506
07/25	8,577	1,971	0	5,821	0	127	657
07/26	11,298	2,343	0	7,920	0	165	871
07/27	13,914	975	259	11,983	0	418	279
07/28	13,034	349	259	11,728	0	349	349
07/29	12,482	395	215	11,082	0	395	395
07/30	11,691	263	260	10,641	0	263	263
07/31	18,108	307	457	16,731	0	307	307
08/01	11,894	614	0	9,865	0	570	846
08/02	7,381	1,806	0	4,720	0	512	343
08/03	10,278	2,076	0	7,085	0	559	557
08/04	11,955	1,966	807	7,417	0	1,563	202
08/05	6,268	1,484	220	3,205	0	1,209	150
08/06	5,983	1,506	178	2,868	0	1,283	149
08/07	4,393	1,018	162	2,293	0	816	104
08/08	5,531	1,712	162	2,146	65	1,257	189
08/09	7,251	2,908	129	2,659	267	892	396
08/10	6,660	2,480	153	2,186	313	1,138	390
08/11	4,692	938	109	617	335	2,358	335
08/12	4,114	474	0	396	127	2,990	127
08/13	7,272	786	34	1,688	276	4,212	276
08/14	15,254	1,389	26	4,168	734	8,203	734
08/15	14,585	4,031	286	2,577	143	7,335	214
08/16	14,075	3,447	224	2,323	1,603	5,978	500
08/17	16,319	1,874	0	1,856	2,150	10,010	429
08/18	13,651	3,792	0	1,264	975	7,258	361
08/19	7,327	2,235	78	606	490	3,468	451
08/20	8,933	2,651	70	716	611	4,310	575
08/21	6,908	2,050	55	554	472	3,332	445
08/22	7,141	1,692	29	73	4,628	483	236
08/23	6,972	1,241	0	206	2,684	2,788	52
08/24	6,678	1,265	70	220	2,663	2,104	355
08/25	3,229	460	51	119	1,931	592	76
08/26	5,113	648	98	152	3,014	701	500
08/27	6,251	1,066	103	192	3,144	1,476	270
08/28	5,284	879	64	179	2,684	1,292	187
08/29	4,681	449	87	43	3,259	523	319
08/30	5,808	527	0	137	4,073	797	275
08/31	2,579	160	0	0	1,460	926	33
09/01	4,931	232	17	35	2,849	1,798	0

Appendix A3.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
09/02	4,906	422	0	106	3,036	1,317	26
09/03	3,413	280	0	83	2,175	854	21
09/04	3,377	281	0	79	2,130	866	20
09/05	4,473	317	0	142	3,080	898	35
09/06	4,013	137	0	0	2,699	1,113	63
09/07	3,772	224	0	67	2,800	666	15
09/08	4,453	78	0	0	3,520	841	13
09/09	1,363	71	0	0	973	297	21
09/10	1,289	51	0	0	984	234	20
09/11	1,204	50	0	0	911	224	19
09/12	2,704	183	0	54	1,767	670	30
09/13	1,389	49	0	0	1,127	205	8
09/14	1,210	79	0	0	953	172	6
09/15	1,295	89	0	30	901	252	23
09/16	2,018	98	0	0	1,612	272	36
09/17	1,571	111	0	0	1,217	203	40
09/18	1,058	77	0	0	794	161	26
09/19	1,999	138	0	0	1,582	227	53
09/20	1,080	78	0	0	823	152	27
09/21	974	68	0	0	769	112	26
09/22	687	46	0	0	511	81	48
09/23	590	36	0	0	412	53	89
09/24	1,157	56	0	0	852	28	221
09/25	371	15	0	0	273	9	74
09/26	297	13	0	0	213	26	45
09/27	423	20	0	0	296	72	36
09/28	477	15	0	0	357	54	52
09/29	604	25	0	0	433	90	56
09/30	603	23	0	0	436	86	58
Total	969,684	512,581	7,698	246,144	78,588	96,167	28,505

APPENDIX B

Appendix B1.-Adjusted daily sonar count and species composition on the east bank of the Togiak River, Alaska during June-September 1990.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	456	456	0	0	0	0	0
06/26	406	406	0	0	0	0	0
06/27	935	935	0	0	0	0	0
06/28	964	964	0	0	0	0	0
06/29	788	788	0	0	0	0	0
06/30	4,146	4,146	0	0	0	0	0
07/01	4,228	4,228	0	0	0	0	0
07/02	5,037	5,037	0	0	0	0	0
07/03	3,925	3,925	0	0	0	0	0
07/04	2,802	2,802	0	0	0	0	0
07/05	1,690	1,690	0	0	0	0	0
07/06	4,136	4,030	0	106	0	0	0
07/07	1,941	1,891	0	50	0	0	0
07/08	7,890	7,591	0	100	0	200	0
07/09	12,626	12,109	0	235	0	282	0
07/10	7,675	7,471	45	158	0	0	0
07/11	9,768	9,247	0	195	0	326	0
07/12	9,111	8,518	54	216	0	323	0
07/13	10,814	10,055	63	316	0	379	0
07/14	14,128	13,137	83	413	0	496	0
07/15	15,361	12,458	134	1,116	0	1,652	0
07/16	9,673	6,973	450	2,025	0	225	0
07/17	10,023	6,960	557	2,367	0	139	0
07/18	11,678	8,554	39	1,250	0	1,836	0
07/19	12,674	10,748	0	561	0	1,243	120
07/20	11,226	10,478	68	340	0	340	0
07/21	9,658	9,014	59	293	0	293	0
07/22	11,543	10,774	70	350	0	350	0
07/23	17,254	15,636	90	1,078	0	449	0
07/24	15,749	14,390	0	663	0	696	0
07/25	13,950	11,890	34	1,250	0	777	0
07/26	12,886	8,921	0	3,634	0	0	330
07/27	14,402	9,970	0	4,062	0	0	369
07/28	11,872	7,265	0	2,835	0	1,772	0
07/29	12,019	7,355	0	2,870	0	1,794	0
07/30	9,795	6,530	544	1,905	0	816	0
07/31	9,193	6,129	511	1,788	0	766	0
08/01	13,892	7,874	64	3,041	0	2,849	64
08/02	19,960	14,301	103	3,910	0	1,543	103
08/03	13,452	3,464	18	1,566	18	8,385	0
08/04	16,094	8,008	0	864	0	7,222	0
08/05	16,524	4,986	0	801	0	10,737	0
08/06	14,925	4,653	0	1,336	0	8,430	507
08/07	15,992	9,478	0	2,327	0	4,188	0
08/08	10,654	5,120	0	1,862	52	3,568	52
08/09	11,201	4,972	0	570	0	5,640	20

Appendix B1.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
08/10	9,000	3,893	0	464	0	4,643	0
08/11	8,499	3,676	0	438	0	4,384	0
08/12	7,374	3,190	0	380	0	3,804	0
08/13	5,398	2,575	0	1,578	0	1,163	83
08/14	6,487	3,686	0	737	0	2,064	0
08/15	5,923	2,446	129	773	386	2,060	129
08/16	5,025	1,874	85	511	511	1,874	170
08/17	5,787	2,077	0	742	297	2,226	445
08/18	2,861	1,027	0	367	147	1,100	220
08/19	2,063	117	0	78	0	817	1,051
08/20	2,257	976	0	244	305	488	244
08/21	2,457	799	0	61	307	430	860
08/22	1,866	607	0	47	233	327	653
08/23	2,527	821	0	63	316	442	884
08/24	1,475	825	0	32	428	190	0
08/25	956	534	0	21	278	123	0
08/26	1,159	648	0	25	336	150	0
08/27	929	519	0	20	270	120	0
08/28	1,143	529	0	28	453	123	9
08/29	2,285	240	0	80	1,764	80	120
08/30	1,531	109	0	27	1,203	82	109
08/31	1,393	59	0	15	1,173	117	29
09/01	1,561	63	0	16	1,325	126	32
09/02	1,232	50	0	12	1,045	100	25
09/03	1,674	86	0	0	1,373	172	43
09/04	2,354	141	0	0	2,003	141	70
09/05	1,768	104	0	0	1,508	104	52
09/06	1,684	92	0	0	1,562	0	31
09/07	1,283	0	0	41	1,241	0	0
09/08	1,555	68	0	34	1,420	34	0
09/09	1,422	62	0	31	1,298	31	0
09/10	891	33	0	17	825	17	0
09/11	597	21	0	10	555	10	0
09/12	507	27	0	0	467	13	0
09/13	802	80	0	0	722	0	0
09/14	1,404	0	0	0	1,404	0	0
09/15	708	0	0	0	708	0	0
09/16	610	0	0	0	610	0	0
09/17	786	0	0	0	786	0	0
Total	544,346	358,377	3,199	53,344	27,329	95,271	6,826

Appendix B2.-Adjusted daily sonar count and species composition on the west bank of the Togiak River, Alaska during June-September 1990.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	214	198	11	5	0	0	0
06/26	104	96	5	3	0	0	0
06/27	132	122	7	3	0	0	0
06/28	141	130	7	4	0	0	0
06/29	497	460	25	12	0	0	0
06/30	963	891	48	24	0	0	0
07/01	1,953	1,807	98	49	0	0	0
07/02	2,181	2,017	109	55	0	0	0
07/03	2,448	2,387	61	0	0	0	0
07/04	1,755	1,711	44	0	0	0	0
07/05	656	640	16	0	0	0	0
07/06	3,014	2,778	59	177	0	0	0
07/07	6,269	5,777	123	369	0	0	0
07/08	7,709	7,104	151	453	0	0	0
07/09	9,681	9,461	0	220	0	0	0
07/10	10,172	9,405	0	768	0	0	0
07/11	9,193	8,756	0	438	0	0	0
07/12	6,796	6,178	0	412	0	206	0
07/13	4,160	2,684	403	805	0	268	0
07/14	10,469	6,755	1,013	2,026	0	675	0
07/15	10,951	7,065	1,060	2,120	0	707	0
07/16	12,690	9,870	705	2,115	0	0	0
07/17	9,698	2,910	970	5,819	0	0	0
07/18	12,287	7,021	658	4,608	0	0	0
07/19	13,027	11,053	0	1,579	0	197	197
07/20	9,832	7,194	480	2,158	0	0	0
07/21	11,536	8,441	563	2,532	0	0	0
07/22	10,202	7,465	498	2,239	0	0	0
07/23	11,940	4,776	398	6,766	0	0	0
07/24	11,084	9,265	28	843	0	947	0
07/25	9,206	6,625	0	2,511	0	70	0
07/26	7,628	6,241	0	1,348	0	39	0
07/27	9,432	7,717	0	1,667	0	48	0
07/28	8,502	6,513	0	1,911	0	78	0
07/29	10,001	7,662	0	2,248	0	92	0
07/30	10,149	3,443	181	6,162	0	181	181
07/31	11,145	3,781	199	6,767	0	199	199
08/01	8,428	4,909	148	2,070	0	1,242	59
08/02	7,581	3,463	0	3,744	0	281	94
08/03	6,425	1,435	0	1,826	0	3,163	0
08/04	10,076	2,879	206	2,879	0	4,113	0
08/05	9,580	860	0	322	0	8,398	0
08/06	3,764	1,389	0	358	0	1,927	90
08/07	4,837	1,307	131	2,222	0	1,089	87
08/08	6,561	3,888	243	1,033	122	1,033	243
08/09	8,351	4,051	312	1,994	125	1,059	810
08/10	7,036	3,347	124	868	0	2,604	93
08/11	6,629	3,154	117	818	0	2,453	88

Appendix B2.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
08/12	4,944	2,352	87	610	0	1,830	65
08/13	2,501	1,330	638	213	0	266	53
08/14	3,020	1,426	84	1,342	0	168	0
08/15	2,254	1,172	316	316	135	225	90
08/16	3,111	1,606	602	401	100	301	100
08/17	2,522	1,368	513	214	85	299	43
08/18	1,378	747	280	117	47	163	23
08/19	1,042	280	0	51	51	635	25
08/20	1,501	662	44	44	132	574	44
08/21	1,480	870	44	305	44	218	0
08/22	1,289	758	38	265	38	190	0
08/23	943	555	28	194	28	139	0
08/24	497	312	12	81	23	58	12
08/25	677	425	16	110	31	79	16
Total	364,244	230,944	11,899	81,614	961	36,213	2,613

Appendix B3.-Adjusted daily sonar count and species composition on both banks of the Togiak River, Alaska during June-September 1990.

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
06/25	670	654	11	5	0	0	0
06/26	510	502	5	3	0	0	0
06/27	1,067	1,057	7	3	0	0	0
06/28	1,105	1,094	7	4	0	0	0
06/29	1,285	1,248	25	12	0	0	0
06/30	5,109	5,037	48	24	0	0	0
07/01	6,181	6,035	98	49	0	0	0
07/02	7,218	7,054	109	55	0	0	0
07/03	6,373	6,311	61	0	0	0	0
07/04	4,557	4,513	44	0	0	0	0
07/05	2,346	2,330	16	0	0	0	0
07/06	7,150	6,807	59	283	0	0	0
07/07	8,210	7,669	123	419	0	0	0
07/08	15,599	14,695	151	553	0	200	0
07/09	22,307	21,570	0	455	0	282	0
07/10	17,847	16,876	45	926	0	0	0
07/11	18,961	18,002	0	633	0	326	0
07/12	15,907	14,696	54	628	0	529	0
07/13	14,974	12,739	466	1,121	0	648	0
07/14	24,598	19,891	1,096	2,439	0	1,171	0
07/15	26,312	19,523	1,194	3,236	0	2,359	0
07/16	22,363	16,844	1,155	4,140	0	225	0
07/17	19,721	9,870	1,527	8,186	0	139	0
07/18	23,965	15,575	697	5,857	0	1,836	0
07/19	25,701	21,802	0	2,141	0	1,441	318
07/20	21,058	17,672	548	2,498	0	340	0
07/21	21,194	17,455	621	2,825	0	293	0
07/22	21,745	18,238	568	2,589	0	350	0
07/23	29,194	20,412	488	7,844	0	449	0
07/24	26,833	23,655	28	1,506	0	1,644	0
07/25	23,156	18,515	34	3,760	0	847	0
07/26	20,513	15,162	0	4,983	0	39	330
07/27	23,834	17,687	0	5,729	0	48	369
07/28	20,373	13,777	0	4,746	0	1,850	0
07/29	22,020	15,016	0	5,118	0	1,886	0
07/30	19,944	9,973	725	8,067	0	997	181
07/31	20,339	9,910	710	8,554	0	965	199
08/01	22,320	12,783	212	5,111	0	4,091	123
08/02	27,541	17,764	103	7,654	0	1,824	196
08/03	19,877	4,899	18	3,393	18	11,548	0
08/04	26,169	10,886	206	3,742	0	11,335	0
08/05	26,104	5,846	0	1,123	0	19,135	0
08/06	18,690	6,042	0	1,694	0	10,357	596
08/07	20,829	10,785	131	4,549	0	5,277	87
08/08	17,215	9,008	243	2,895	173	4,601	295
08/09	19,552	9,023	312	2,564	125	6,699	830
08/10	16,035	7,240	124	1,332	0	7,246	93
08/11	15,128	6,830	117	1,256	0	6,837	88

Appendix B3.-Continued

Date	Total	Sockeye	Chinook	Chum	Coho	Pink	Other
08/12	12,318	5,542	87	990	0	5,634	65
08/13	7,899	3,905	638	1,791	0	1,429	136
08/14	9,507	5,112	84	2,080	0	2,232	0
08/15	8,177	3,618	444	1,088	522	2,286	219
08/16	8,137	3,480	687	913	611	2,175	271
08/17	8,309	3,445	513	956	382	2,525	488
08/18	4,239	1,774	280	484	193	1,264	243
08/19	3,105	396	0	129	51	1,453	1,076
08/20	3,758	1,638	44	288	437	1,062	288
08/21	3,937	1,669	44	366	351	648	860
08/22	3,155	1,365	38	312	271	516	653
08/23	3,470	1,376	28	257	344	581	884
08/24	1,972	1,137	12	113	451	248	12
08/25	1,632	959	16	131	309	202	16
08/26	1,159	648	0	25	336	150	0
08/27	929	519	0	20	270	120	0
08/28	1,143	529	0	28	453	123	9
08/29	2,285	240	0	80	1,764	80	120
08/30	1,531	109	0	27	1,203	82	109
08/31	1,393	59	0	15	1,173	117	29
09/01	1,561	63	0	16	1,325	126	32
09/02	1,232	50	0	12	1,045	100	25
09/03	1,674	86	0	0	1,373	172	43
09/04	2,354	141	0	0	2,003	141	70
09/05	1,768	104	0	0	1,508	104	52
09/06	1,684	92	0	0	1,562	0	31
09/07	1,283	0	0	41	1,241	0	0
09/08	1,555	68	0	34	1,420	34	0
09/09	1,422	62	0	31	1,298	31	0
09/10	891	33	0	17	825	17	0
09/11	597	21	0	10	555	10	0
09/12	507	27	0	0	467	13	0
09/13	802	80	0	0	722	0	0
09/14	1,404	0	0	0	1,404	0	0
09/15	708	0	0	0	708	0	0
09/16	610	0	0	0	610	0	0
09/17	786	0	0	0	786	0	0
Total	908,590	589,321	15,098	134,958	28,290	131,484	9,439

APPENDIX C

Appendix C1.-Mean length and sex ratio of chinook salmon captured in the beach seine and in 12, 14, and 20 cm stretch mesh gill nets in the Togiak River, Alaska during 1988 and 1990.

Year	Gear Type	Length				Sex	
		N	Mean	SD	Range	Ratio (♂:♀)	Percent (♂:♀)
				1988			
Male	12 cm Gillnet	6	597.3	184.9	416-916		
Female	12 cm Gillnet	4	806.8	146.7	587-889		
All	12 cm Gillnet	10	681.1	194.6	416-916	1.0:0.7	60:40
Male	14 cm Gillnet	1	636.0	-	_		
Female	14 cm Gillnet	0	-	-	-	-	-
All	14 cm Gillnet	1	636.0	-	_	1.0:0.0	100:0
Male	20 cm Gillnet	9	851.2	116.5	672-1007		
Female	20 cm Gillnet	48	895.5	52.1	766-976		
All	20 cm Gillnet	57	888.4	67.2	672-1007	1.0:5.3	16:84
All	Beach Seine	0	-	-	-	-	-
Male	Combined Gear	16	742.6	186.9	416-1007		
Female	Combined Gear	52	888.6	66.1	587-976		
All	Combined Gear	68	853.7	123.2	416-1007	1.0:3.3	24:76
				1990			
Male	12 cm Gillnet	14	773.9	168.9	496-955		
Female	12 cm Gillnet	8	772.6	134.9	542-907		
All	12 cm Gillnet	22	773.4	154.0	496-955	1.0:0.6	64:36
Male	14 cm Gillnet	4	591.8	119.2	447-734		
Female	14 cm Gillnet	7	807.1	65.5	739-945		
All	14 cm Gillnet	11	728.8	136.6	447-945	1.0:1.8	36:64
Male	20 cm Gillnet	19	689.8	190.6	417-985		
Female	20 cm Gillnet	12	838.8	45.8	753-929		
All	20 cm Gillnet	31	747.5	167.4	417-985	1.0:0.6	61:39
Male	Beach Seine	0	-	-	-	-	-
Female	Beach Seine	2	848.5	30.4	827-870		
All	Beach Seine	2	848.5	30.4	827-870	1.0:0.0	100:0
Male	Combined Gear	37	711.0	181.7	417-985		
Female	Combined Gear	29	813.6	84.7	542-945		
All	Combined Gear	66	756.1	154.9	417-985	1.0:0.8	56:44

Appendix C1.-Continued.

Year	Gear Type	Length N	Length Mean	Length SD	Length Range	Sex Ratio (♂:♀)	Sex Percent (♂:♀)
			1988/1990				
Male	12 cm Gillnet	20	720.9	188.2	416-955		
Female	12 cm Gillnet	12	784.0	133.2	542-907		
All	12 cm Gillnet	32	744.6	170.2	416-955	1.0:0.6	63:37
Male	14 cm Gillnet	5	600.6	105.1	447-734		
Female	14 cm Gillnet	7	807.1	65.5	739-945		
All	14 cm Gillnet	12	721.1	132.9	447-945	1.0:1.4	42:58
Male	20 cm Gillnet	28	741.7	184.8	417-1007		
Female	20 cm Gillnet	60	884.0	55.5	753-976		
All	20 cm Gillnet	88	838.2	131.4	417-1007	1.0:2.1	32:68
Male	Beach Seine	0	-	-	-	-	-
Female	Beach Seine	2	848.5	30.4	827-870		
All	Beach Seine	2	848.5	30.4	827-870	1.0:0.0	100:0
Male	Combined Gear	53	720.5	182.0	416-1,007		
Female	Combined Gear	81	861.4	81.4	542-976		
All	Combined Gear	134	805.3	147.7	416-1,007	1.0:1.5	40:60

Appendix C2.-Mean length and sex ratio of chum salmon captured in the beach seine and in 12, 14, and 20 cm stretch mesh gill nets in the Togiak River, Alaska during 1988 and 1990.

Year	Gear Type	Length				Sex	
		N	Mean	SD	Range	Ratio (♂:♀)	Percent (♂:♀)
1988							
Male	12 cm Gillnet	426	616.2	28.9	540-725		
Female	12 cm Gillnet	68	581.9	29.5	502-667		
All	12 cm Gillnet	494	611.5	31.3	502-725	1.0:0.2	86:14
Male	14 cm Gillnet	28	631.0	26.6	573-695		
Female	14 cm Gillnet	3	589.0	17.3	579-609		
All	14 cm Gillnet	31	626.9	28.5	573-695	1.0:0.1	90:10
Male	20 cm Gillnet	21	641.4	21.5	604-674	1.0:0.0	100:0
Female	20 cm Gillnet	0	-	-	-		
All	20 cm Gillnet	21	641.4	21.5	604-674	1.0:0.0	100:0
Male	Beach Seine	2	643.0	24.0	626-660		
Female	Beach Seine	1	620.0	-	620		
All	Beach Seine	3	635.3	21.6	620-660	1.0:0.5	67:33
Male	Combined Gear	477	618.3	29.1	540-725		
Female	Combined Gear	72	582.7	29.2	502-667		
All	Combined Gear	549	613.7	31.5	502-725	1.0:0.2	87:13
1990							
Male	12 cm Gillnet	151	581.1	34.9	484-653		
Female	12 cm Gillnet	59	525.4	35.0	467-599		
All	12 cm Gillnet	210	565.5	42.9	467-653	1.0:0.4	72:28
Male	14 cm Gillnet	80	615.8	37.5	524-703		
Female	14 cm Gillnet	23	549.3	42.3	481-638		
All	14 cm Gillnet	103	601.0	47.4	481-703	1.0:0.3	78:22
Male	20 cm Gillnet	39	620.9	34.1	557-701	1.0:0.0	100:0
Female	20 cm Gillnet	0	-	-	-	-	-
All	20 cm Gillnet	39	620.9	34.1	557-701	1.0:0.0	100:0
Male	Beach Seine	33	590.5	45.4	410-669		
Female	Beach Seine	25	541.1	27.7	450-703		
All	Beach Seine	58	569.2	45.7	410-703	1.0:0.8	57:43
Male	Combined Gear	303	596.4	40.4	484-703		
Female	Combined Gear	107	534.2	36.3	450-638		
All	Combined Gear	410	580.2	47.9	450-703	1.0:0.4	74:26

Appendix C2.-Continued.

Year	Gear Type	Length N	Length Mean	Length SD	Length Range	Sex Ratio (♂:♀)	Sex Percent (♂:♀)
			1988/1990				
Male	12 cm Gillnet	577	607.1	34.3	484-725		
Female	12 cm Gillnet	127	555.7	42.7	467-667		
All	12 cm Gillnet	704	597.8	41.0	467-725	1.0:0.2	82:18
Male	14 cm Gillnet	108	619.8	35.5	524-703		
Female	14 cm Gillnet	26	553.8	42.0	481-638		
All	14 cm Gillnet	134	607.0	45.1	481-703	1.0:0.2	81:19
Male	20 cm Gillnet	60	628.1	31.7	557-701	1.0:0.0	100:0
Female	20 cm Gillnet	0	-	-	-		
All	20 cm Gillnet	60	628.1	31.7	557-701	1.0:0.0	100:0
Male	Beach Seine	35	593.5	46.0	488-669		
Female	Beach Seine	26	544.1	31.3	450-620		
All	Beach Seine	61	572.4	47.0	450-669	1.0:0.7	57:43
Male	Combined Gear	780	609.8	35.6	484-725		
Female	Combined Gear	179	553.7	41.1	450-667		
All	Combined Gear	959	599.3	42.7	450-725	1.0:0.2	81:19

Appendix C3.-Mean length and sex ratio of coho salmon captured in the beach seine and in 12, 14, and 20 cm stretch mesh gill nets in the Togiak River, Alaska during 1987, 1988 and 1990.

Year	Gear Type	Length				Sex	
		N	Mean	SD	Range	Ratio (♂:♀)	Percent (♂:♀)
				1987			
All	12 cm Gillnet	0	-	-	-	-	-
Male	14 cm Gillnet	163	592.9	46.5	429-690		
Female	14 cm Gillnet	93	588.4	38.5	484-671		
All	14 cm Gillnet	256	591.3	43.7	429-690	1.0:0.6	64:36
All	20 cm Gillnet	0	-	-	-	-	-
Male	Beach Seine	11	567.1	53.0	474-650		
Female	Beach Seine	1	646.0	0.0	646-646		
All	Beach Seine	12	573.7	55.4	474-650	1.0:0.1	92:8
Male	Combined Gear	174	591.3	47.2	429-690		
Female	Combined Gear	94	589.0	38.8	484-671		
All	Combined Gear	268	590.5	44.3	429-690	1.0:0.5	65:35
				1988			
Male	12 cm Gillnet	99	584.5	52.1	431-674		
Female	12 cm Gillnet	108	587.2	38.3	471-645		
All	12 cm Gillnet	207	585.9	45.3	431-674	1.0:1.1	48:52
Male	14 cm Gillnet	85	616.8	38.7	483-693		
Female	14 cm Gillnet	109	599.4	32.5	483-698		
All	14 cm Gillnet	194	607.0	36.3	483-698	1.0:1.3	44:56
Male	20 cm Gillnet	0	-	-	-		
Female	20 cm Gillnet	1	557.0	-	557	0.0:1.0	100:0
All	20 cm Gillnet	1	557.0	-	557	0.0:1.0	100:0
All	Beach Seine	0	-	-	-	-	-
Male	Combined Gear	184	599.4	49.0	431-693		
Female	Combined Gear	218	593.2	36.0	471-698		
All	Combined Gear	402	596.0	42.5	431-698	1.0:1.2	46:54

Appendix C3.-Continued.

Year	Gear Type	Length N	Length Mean	Length SD	Length Range	Sex Ratio (♂:♀)	Sex Percent (♂:♀)
			1990				
Male	12 cm Gillnet	132	590.0	40.3	479-671		
Female	12 cm Gillnet	113	580.4	36.2	450-641		
All	12 cm Gillnet	245	585.6	38.6	450-671	1.0:0.9	54:46
All	14 cm Gillnet	0	-	-	-	-	-
All	20 cm Gillnet	0	-	-	-	-	-
All	Beach Seine	0	-	-	-	-	-
Male	Combined Gear	132	590.0	40.3	479-671		
Female	Combined Gear	113	580.4	36.2	450-641		
All	Combined Gear	245	585.6	38.6	450-671	1.0:0.9	54:46
			1987/1988/1990				
Male	12 cm Gillnet	231	587.6	45.7	431-674		
Female	12 cm Gillnet	221	583.7	37.3	450-645		
All	12 cm Gillnet	452	585.7	41.8	431-674	1.0:1.0	51:49
Male	14 cm Gillnet	248	601.1	45.3	429-693		
Female	14 cm Gillnet	202	594.4	35.7	483-698		
All	14 cm Gillnet	450	598.1	41.4	429-698	1.0:0.8	55:45
Male	20 cm Gillnet	0	-	-	-		
Female	20 cm Gillnet	1	557.0	-	-		
All	20 cm Gillnet	1	557.0	-	-	0.0:1.0	100:0
Male	Beach Seine	11	571.6	52.2	474-650		
Female	Beach Seine	1	646.0	0.0	646-646		
All	Beach Seine	12	573.7	55.4	474-650	1.0:0.2	83:17
Male	Combined Gear	490	593.9	46.2	429-693		
Female	Combined Gear	425	588.9	37.0	450-698		
All	Combined Gear	915	591.6	42.2	429-698	1.0:0.9	54:46

Appendix C4.-Mean length and sex ratio of pink salmon captured in the beach seine and in 12, 14, and 20 cm stretch mesh gill nets in the Togiak River, Alaska during 1990.

Year	Gear Type	Length				Sex	
		N	Mean	SD	Range	Ratio (♂:♀)	Percent (♂:♀)
				1990			
Male	12 cm Gillnet	60	438.7	30.0	379-503		
Female	12 cm Gillnet	64	430.0	15.7	381-481		
All	12 cm Gillnet	124	434.2	24.0	379-503	1.0:1.1	48:52
Male	14 cm Gillnet	7	443.9	23.7	413-486		
Female	14 cm Gillnet	-	-	-	-		
All	14 cm Gillnet	7	443.9	23.7	413-486	1.0:0.0	100:0
Male	20 cm Gillnet	-	-	-	-		
Female	20 cm Gillnet	-	-	-	-		
All	20 cm Gillnet	-	-	-	-	-	-
Male	Beach Seine	35	424.5	27.7	380-485		
Female	Beach Seine	34	412.0	24.7	354-456		
All	Beach Seine	69	418.3	26.8	354-485	1.0:1.0	51:49
Male	Combined Gear	102	434.2	29.3	379-503		
Female	Combined Gear	98	423.7	21.0	354-481		
All	Combined Gear	200	429.1	26.1	354-503	1.0:1.0	51:49

Appendix C5.-Mean length and sex ratio of sockeye salmon captured in the beach seine and in 12, 14, and 20 cm stretch mesh gill nets in the Togiak River, Alaska during 1988 and 1990.

Year	Gear Type	Length				Sex	
		N	Mean	SD	Range	Ratio (♂:♀)	Percent (♂:♀)
1988							
Male	12 cm Gillnet	190	603.1	29.4	472-692		
Female	12 cm Gillnet	257	567.0	28.9	461-633		
All	12 cm Gillnet	447	582.3	34.1	461-692	1.0:1.4	43:57
Male	14 cm Gillnet	43	609.2	23.4	550-648		
Female	14 cm Gillnet	50	573.8	25.0	517-623		
All	14 cm Gillnet	93	590.2	30.0	517-648	1.0:1.2	46:54
Male	20 cm Gillnet	8	628.1	23.2	586-653		
Female	20 cm Gillnet	3	564.0	18.0	549-584		
All	20 cm Gillnet	11	610.6	36.6	549-653	1.0:0.4	73:27
Male	Beach Seine	10	603.8	32.8	544-660		
Female	Beach Seine	12	564.3	26.2	513-603		
All	Beach Seine	22	582.2	35.0	513-660	1.0:1.2	45:55
Male	Combined Gear	251	604.9	28.7	472-692		
Female	Combined Gear	322	568.1	27.9	461-633		
All	Combined Gear	573	584.4	33.7	461-692	1.0:1.3	44:56
1990							
Male	12 cm Gillnet	40	550.8	39.0	486-637		
Female	12 cm Gillnet	33	519.6	39.2	458-594		
All	12 cm Gillnet	73	536.7	41.9	458-637	1.0:0.8	55:45
Male	14 cm Gillnet	233	572.9	39.3	472-650		
Female	14 cm Gillnet	199	543.3	33.9	454-608		
All	14 cm Gillnet	432	559.2	39.7	454-650	1.0:0.9	54:46
Male	20 cm Gillnet	7	573.1	34.0	513-624		
Female	20 cm Gillnet	12	536.8	35.7	454-573		
All	20 cm Gillnet	19	550.2	38.6	454-624	1.0:1.7	37:63
Male	Beach Seine	44	552.7	45.8	424-630		
Female	Beach Seine	60	524.0	39.9	403-595		
All	Beach Seine	104	536.1	44.6	403-630	1.0:1.4	42:58
Male	Combined Gear	324	567.4	41.0	424-650		
Female	Combined Gear	304	536.6	36.9	403-608		
All	Combined Gear	628	552.5	42.0	403-650	1.0:0.9	52:48

Appendix C5.-Continued.

Year	Gear Type	Length N	Length Mean	Length SD	Length Range	Sex Ratio (♂:♀)	Sex Percent (♂:♀)
			1988/1990				
Male	12 cm Gillnet	230	594.0	37.0	472-692		
Female	12 cm Gillnet	290	561.6	33.7	458-633		
All	12 cm Gillnet	520	575.9	38.7	458-692	1.0:1.3	44:56
Male	14 cm Gillnet	276	578.5	39.5	472-650		
Female	14 cm Gillnet	249	549.4	34.5	454-623		
All	14 cm Gillnet	525	564.7	39.9	454-650	1.0:0.9	53:47
Male	20 cm Gillnet	15	602.5	39.6	513-653		
Female	20 cm Gillnet	15	542.3	34.3	454-584		
All	20 cm Gillnet	30	572.4	47.6	454-653	1.0:1.0	50:50
Male	Beach Seine	54	562.2	47.8	424-660		
Female	Beach Seine	72	530.7	40.7	403-603		
All	Beach Seine	126	544.2	46.4	403-660	1.0:1.2	43:57
Male	Combined Gear	575	583.8	40.6	424-692		
Female	Combined Gear	626	552.7	36.2	403-633		
All	Combined Gear	1,201	567.6	41.4	403-692	1.0:1.1	48:52